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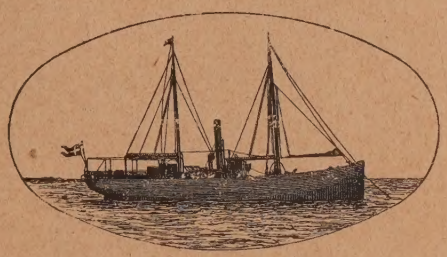
Report

of

The Danish Biological Station

to

The Board of Agriculture.



XV and XVII.

1908.

By

C. G. Joh. Petersen,
Ph. D.

Translated from „Fiskeri-Beretning for 1907".

Copenhagen.
Centraltrykkeriet.
1908.

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First Report

on the

Oysters and Oyster Fisheries in the Lim Fjord

with one Chart, temperature-curves, 3 tables and 2 figures in the text.

by

C. G. Joh. Petersen.

Technical Adviser to the Department of Agriculture in matters concerning the oyster fisheries.

Preface.

After I had been appointed, in 1905, Adviser to the Department of Agriculture in matters concerning the oyster fisheries, I endeavoured, partly through investigations in the Lim Fjord, partly through communicaiions with those interested in the oyster fisheries and partly through the study of the available publications and official documents, to gain some knowledge of what had really happened to the oyster fisheries in the Lim Fjord since their beginning in the year 1852. No connected account namely was available regarding this matter, and a good deal of confusion reigned. I considered it advisable therefore to bring together what I had collected before the present contract ran out. The summary of the earlier history has been prepared with the help partly of the Office for Crown Lands and partly of the Office of Public Records. Two men have helped me greatly, namely, Permanent Secretary, Mr. *P. L. Holm Jørgensen* and Justitsraad, Ritmester *Paulsen*, the latter of whom has had a good deal to do personally with the oyster fisheries for many years; to both I would tender here my thanks for their assistance.

The reason why I have not at the same time drawn up an account of the conditions prevailing on the other oyster banks within the sea-territory of Denmark, namely, at the Skaw (the »Fladstrand« oysters) and on the west coast of Schleswig on the North Sea (the so-called Flensborg oysters), is that they are without importance for the practical fisheries and quite without interest in comparison with the banks in the Lim Fjord. The rich production on the latter is clearly sufficient to provide Denmark with oysters, even if the consumption became much greater than it is now.

Copenhagen, April 1907.

The Author.

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A. Historical Summary.

Of the Danish publications on the oyster and the biology of the oyster may be mentioned the following:

H. Krøyer: De danske Østersbanker 1837.

D. F. Eschricht: Om den kunstige Østersavl i Frankrig og om Anlæg af kunstige Østersbanker i Limfjorden. Two reports to the Minister of Finance. Printed by order of the Minister of Finance 1860.

Eschricht reports here on the endeavour of Professor *Coste* to form new oyster banks on the open coasts of France at places where these had not been present earlier. Coste's experiments had just begun at that time and seemed to

[1]) Appendices II—VII are omitted in the English translation, as they are of interest to restricted Danish circles only; they contain partly the terms of contract between the Government and the contracting Oyster Companies, partly also the conditions of sale.

show prospect of success; it proved later however that in certain ways they were based on erroneous principles. Coste's ideas had great influence on Eschricht and on his proposals to the Danish Government. He proposed namely to improve the whole breed in the Lim Fjord by the introduction of new oysters, and suggested likewise that the experiment should specially be made of forming new banks by transplanting full-grown oysters. To induce private people to form such banks, he further proposed that the fjord should be let in small parcels (as in France), with exclusive rights to the lesssees to form such banks. They should further have some recompense if successful. This was the beginning of the whole matter.

J. Collin: Om Østersfiskeriet i Limfjorden. Two lectures. (Tidsskrift for populære Fremst. af Naturvidenskaben. 4 R. 3. B. 1871).

J. Collin: Kort Udsigt over Limfjordens Østersbanker (Tidsskrift for Fiskeri 1871).

G. Winther: Aarhusbugten undersøgt med Hensyn til Anlæg af kunstige Østersbanker.

G. Winther: Om vore Haves Naturforhold med Hensyn til kunstig Østersavl og om de i den Henseende anstillede Forsøg. (Af Nordisk Tidsskrift for Fiskeri (Ny Række af Tidsskrift for Fiskeri). Anden og tredje Aargang. 1875 og 1876).

The author explains that he himself had never visited the oyster banks in the Lim Fjord and complains, loc. cit. p. 193: »how great a need there is of a systematic rational investigation, according to most recent methods and with constant regard for the hydrographical and faunistic questions of the present day, of these waters so extremely important for the oyster fishery«.

»*Aktstykker*« (Documents) concerning the representation of the earlier contractors for the oyster fisheries in the Lim Fjord to the »Folketing« and referred by the latter to the Minister of Finance, with regard to compensation from the treasury. 1879.

J. Collin: Om Limfjordens tidligere og nuværende marine Fauna. 1884. In this general information is given on the fauna of the Lim Fjord.

C. G. Joh. Petersen: Om de skalbærende Molluskers Udbredningsforhold i de danske Have indenfor Skagen. 1888.

It is explained in this why the oysters can no longer live in our fjords and sounds round Funen, Zealand and in East Jutland. The hydrographical conditions have namely changed since the period of the »kitchen middens«, and several other shell-fish have also died out since then.

H. Tonning: L'Ostrèiculture. Copenhague. 1893.

The author states in the preface: »Cet opuscule n'a pas la prétention d'être un ouvrage scientifique. J'ai cependant l'espoir, qu'il contienne ça et là quelques renseignements d'un intèrêt sérieux pour les progrès de l'ostrèiculture«.

Good information concerning the distribution of the oyster when discovered in the Lim Fjord about 1850 is given in H. Krøyer's three reports to the Director of Crown Lands; his reports are of considerable general interest and may therefore be reprinted here.

H. Krøyer's Report. 1851.

As soon as the Royal Commission, to whom the task was delegated of draughting improved legislation for the Lim Fjord fisheries, had completed its labours at Nibe, I betook myself without delay to Lemvig, in order to make investigation of the oyster bank said to be there according to a report to the Ministry from the Amtmand of the district Ringkjøbing, Greve Schulin. As the result of this investigation I beg to submit the following report.

The small and narrow bay of the Lim Fjord running from north to south at the end of which Lemvig is situated, has a depth of three to four, even five fathoms at some places, but as a rule the depth is much less. The bottom is partly sand, sand and gravel mixed, large stones and partly also soft alluvial clay. Vegetation, of Zostera etc., appears here and there but it seems to me not very richly. The water is of considerable salinity, so much so that a salt factory has been set up within recent years in Lemvig. On account of the sheltered position of the bay there can be no strong currents or collecting of the broken ice there in the spring.

Under such conditions, so favourable to the preservation and production of oysters, I found if not an actual bank yet a by no means small number of oysters scattered or distributed here and there, not quite equally but in varying quantities, and it seemed to me that most were collected together on the west side of the bay (the side most sheltered from the currents), especially on gravelly bottom at a depth of four to six feet, with none on pure sand bottom. The size of the oysters observed here was considerable; I even believe that they were larger than any I have seen elsewhere in Denmark or in Norway. Very few of the specimens showed in their shells signs of old age, on the contrary, the majority were thin-shelled or might be considered from the nature of the shell as about three to four years old. The quality of these oysters will prove to be very good at the right time of year. On not a few I observe young oysters growing; on the other hand I never found empty shells; although the fauna in this part of the Lim Fjord has almost the same character as in the open sea or in other words, although almost the same small forms of animal life live in company with the oysters at Lemvig as for example on the Schleswig banks, yet I never met with many of the forms which are harmful to the oyster, namely, of star-fish very few and of crabs not any.

In carrying out these investigations I was supported in the most friendly manner by Kancelliraad Voigt, Sheriff of the town and district, and it was due to his instructions and help that the investigation was both relatively easy and quickly brought to an end.

The apparatus used consisted partly of an oyster dredge brought by myself, which however was found to be too small and light to be used with success on the hard gravelly bottom, partly an instrument something like an iron rake but

with the teeth somewhat crooked, by means of which the oysters were taken up in the shallower parts, partly also finally a diving apparatus broght from Harboøre for the greater depths with stony bottom. The rake mentioned is perhaps the most serviceable apparatus for collecting the oysters under the conditions at that place, as it is just suited for use in shallower water where most oysters seem to occur. In using it however, one must be able to see the oysters on the bottom, and it can also only be used when there is no great movement in the water; which should not however be any considerable hindrance in the way of the fishery, as the fishermen should be able to collect in good weather the quantity of oysters they need and put them in boxes or other suitable places where they are easily got at when wanted. This is the method used in Norway where the oyster fishery proceeds everywhere, so far as I have had the opportunity to investigate, in shallow water and with apparatus more or less similar to the rake mentioned.

There can be no doubt that the occurrence of the oysters in the Lim Fjord is certainly connected with the breaking through of the North Sea, and that like the lugworm (Arenicola piscatorum Lam) and several other marine forms they only entered after this natural phenomenon into the western part of the Lim Fjord, where the conditions at several places seem also to be very favourable to their reproduction and growth.

It was due quite to chance that the presence of oysters was observed at Lemvig. It happened that a stone-layer of that town, by name Kristian Hede, was taking up stones from the bed of the fjord for a pavement and observed the oysters; he then constructed the above-mentioned rake and collected a few by its means and sold them in the town. In this way the officials of the town became acquainted with the matter, closed the bank and sent in a report to the Government. But it is at the least very probable that oysters must exist in several other bays and creeks of the western Lim Fjord, where no one as yet has had the opportunity to observe them or where the ignorance of the inhabitants with oysters has perhaps made observations unfruitful. As regards Sallingsund, I have on this journey heard it stated with assurance by a sailor, (mate of the steamboat Odin) from his own experience, that oysters occur in the neighbourhood of Nykjøbing on Mors. And the same person states, though only from the reports of others, that oysters are likewise said to be found on two reefs north of Livø. In any case I consider it certain that several of the Lim Fjord bays, even though oysters may not as yet have found their way in there, are well suited to oyster culture, and thus that a by no means despicable source of income could be opened up for a portion of the inhabitants along the fjord.

The question immediately arises therefore, how can the exploitation of these oyster banks at Lemvig and of all the oyster banks, which will certainly yet be found or laid down in the Lim Fjord, be arranged in the most advantageous manner. Should they be declared crown property (even where so-called cooperative fishery occurs) or made free? And in the first case, should the Lemvig banks be at once contracted out, or should a more exact knowledge of the distribution of the oysters in the Lim Fjord be sought for first of all? In whatever direction the question may be settled in general, I venture to suggest with regard to the Lemvig Bank, that since this bank is as yet

not very rich, it might perhaps be considered an advantage to preserve it for a couple of years and keep a constant watch as to whether the protection causes any appreciable increase. I do not believe however, that if at once contracted out it would run any risk of being quite destroyed, as the oysters living in the deeper water and on stony ground could neither be taken with the dredge or rake, and are thus fairly safe from the fishermen. On the other hand, the oyster belt which extends from four to six feet of water would soon probably be cleaned out, as it is so easily got at, and the fishermen would have in the high prices for oysters a strong stimulus to carrying on an advantageous and but little difficult mode of livelihood.

If the bank mentioned were to be considered as crown property and contracted out, its discoverer, Kristian Hede, might perhaps be reasonably recommended for a small reward; especially as it would be an inducement to others to make the neighbouring stretches of the Lim Fjord the object of close investigation.

Kjøbenhavn, 23rd July 1851.

Most respectfully ,

Henrik Krøyer.

H. Krøyer's Report. 1852.

Having concluded the investigation of the Lim Fjord oyster banks entrusted to me, as far that is as the shortness of the time permitted it, I hasten to respectfully submit the results obtained.

1) According to the statements of both the fishermen and others acquainted with the matter, no oysters have ever been detected in that part of the Lim Fjord which extends between Hals and Løgstør grounds. The result of experiments with the oyster dredge gave further confirmation of this. In Løgstør Bredning, Feggesund and Thisted Bredning as also the arm of the Lim Fjord which separates Mors from Thyland, oysters are still absent, or if found they occur but rarely and singly and thus could not be the object of a fishery. Although experiments induced by the catch of oysters elsewhere in the Lim Fjord have been made at several places in the neighbourhood of Thisted, these have hitherto given no result and the people have been restricted to the oysters obtainable over Nykøbing. Sallingsund right from Glyngøre down to Kaas has been fairly well provided with oysters, especially however on the Salling side, and it is here that the greatest part of the Lim Fjord oysters met with in trade are taken; for this reason also I have made a special point of investigating as far as possible the present condition on this stretch. The result I have arrived at is not very pleasant; with exception of a small strip right in at the head of Harrevig and a point running out from Mors just at the mouth of this bay — Sillerslev Øre — the whole stretch seems to be quite devoid of any oysters of commercial value, on account of the harmful fishery. And it will therefore be necessary to deal carefully and cautiously with this part for some years, so as to give the oysters an opportunity to increase. In the south beyond Jegindø and Kaas we come to the broads round about Wenø. In this I have observed oysters at the following places: near Struer, though

only in small quantity; more abundant about 1 mile north of Struer at the neck which extends out east of Strandbjærggaard (Adskjer Odde), also 4 miles east of Struer opposite the fishing place Snøden about halfway between Volstrupgaard and Handbjærggaard; lastly and in greatest quantity off Eising Sogn at Nygaards Hage 3 miles or somewhat more to the north of Snøden. Although some oysters are fished here and sent to Holstebro, yet the fishery has not been overdone as at Saltingsund, and the banks therefore are relatively in a better condition. Leaving these broads and passing through Ottesund into Nissum Bredning, we find, so far as I have experienced, not a trace of oysters on its nothern and eastern coasts or at Thyland, whereas the whole of the south coast or the coast of the Skodborg and Vandfuld districts contains oysters, though at most places only in small numbers. The principal places, so far as known, are Lemvig Bay, especially at Kabbel-Odde and Helleris-Odde as also outside this bay 2 miles west on the coast off Hygom-Sogn. This stretch is almost never fished. Although the weather was favourable to my investigations in high degree and enabled me to visit a not inconsiderable part of the Lim Fjord, yet on the other hand the shortness of the time prevented me from taking into regard various places which otherwise I should have liked to include in the investigation. Concerning the conditions I can therefore only state what was told me at Nykjøbing, namely, that oysters were said to have been found in these parts (in the south and east) yet only in small quantities, and that they were already removed or the banks emptied. I believe I may consider it of little importance that I was unable to visit the large branch of the Lim Fjord which extends in a southerly direction from Løgstør down towards Skive and Viborg, as I have never once heard that any trace of oysters has hitherto been met with there.

2) After giving a general account of the occurrence of the oysters in the Lim Fjord, I may touch upon the special local conditions under which they are found, and which seem here not only favourable but almost absolutely necessary for them. They are found near the land in small depths of about 2—4—6 feet and on bottom consisting of gravel and small stones resting on clay.

On pure and fine sand on the other hand they are but seldom seem, probably because the spat are not able to fix themselves there. They are met with in greater depths, thus 7 to 9 feet or perhaps somewhat more, wherever there is stony ground, but in depths of 3 to 4 fathoms and more they never seem to occur, even though the bottom may be the same as on the shallow banks, namely mud. As I had brought a capable oyster fisherman with me from Frederikshavn, just for the purpose of having the deep water investigated by means of the dredge, and as repeated trials with this apparatus have been quite without result, not even bringing up empty shells, I belive we may consider it as fairly certain, that no oysters live as a rule in deep water in the Lim Fjord, which may probably be ascribed to the strong current, as the bottom cannot be regarded as unsuitable.

An unexpected feature in the occurrence of the oysters is further the cir-

cumstance, that they were found in quantities at places where streams flow out into the fjord, and where the water has thus a less salinity than usual. The oysters are on the whole widely scattered and single, more rarely two or three fixed together. On account of the general situation of the banks, the fishery here must be light, simple and inexpensive, which is of no small importance in respect to the farming out of the beds. In Sallingsund a so-called »brile« is used for the fishery; it is a small iron barrel-hoop fixed on the end of a 10 to 12 feet long pole and provided with a bag of wide-meshed netting. At Lemvig a kind of rake was used with 4 or 5 teeth of 4 inch nails. Wherever the oysters occur in quantity the fishermen according to my experience should be able to take up about half a hundred in half an hour; and this agrees fairly well with what experienced fishermen have told me, that they have fished 1200—1500 oysters per day. The fishing cannot be carried on in all kinds of weather, but requires calm and sunshine, when the oysters are most readily and most distinctly seen on the bottom. The oyster dredge is here not only unnecessary but even useless. This apparatus is namely adapted to soft bottom; it does not penetrate into the hard gravelly bottom and is thus dragged over the oysters without taking them. When it is stated in the report that the oysters are right on the shore, so that the water does not rise above the wooden shoes of the collector, this may apply perhaps to one or another single oyster, but is to be regarded as an exaggeration in any question of the oyster fishery.

3) As regards the nature of the oysters in the Lim Fjord, they possess certain peculiarities which make them easily recognizable to the trained eye, and separate them from the »fladstrand« oysters. They are large, but very flat and thin, almost leaf-like, and the shell has an obvious green colour. The animals themselves I have as a rule found to be bluish-white, fairly lean and inferior in taste to the »fladstrand« oysters. The consumers all say also that the Lim Fjord oysters are too insipid and sweet to the taste. and cannot be eaten without salt etc. In the trade they will therefore probably have a less value than the »fladstrand« oysters, though they have almost the same size, a circumstance which will come into consideration in any farming out of the beds, and which may be said to neutralise to a great extent the advantage arising from the easy method of fishing in comparison with the »fladstrand« oysters. What seems to me to characterize the Lim Fjord banks in contrast both to the »fladstrand« and Schleswig banks, so far as these are known to me, is the large quantity of the growth-stages or spat one finds on them; the small oysters, sometimes so small that they can scarcely be seen with the naked eye, are frequently found on both adult oysters and empty shells of mussels etc. This means that the banks should thrive well and even where they are now spoilt, should recover fairly quickly if protected for a couple of years. There seems also to be an excellent opportunity for the eventual contractors or others to establish oysters ponds with advantage. On the other hand, it would be desirable if the too great production of the animals harmful to the oysters, star-fish etc. could be restricted. These are found already in somewhat considerable quantities on the banks.

4) I come now the questition, whetcher the oyster banks of the Lim Fjord as a consequence of their situation are so shut off that the authorities concerned, as has been stated, are unable to protect them from unlawful fishing. I feel obliged to contradict this statement absolutely, and to maintain the opposite, that if a bank is plundered the fault lies not at all with the situation but in the indifference of the police, and as sufficient proof of this I may point out that the banks round Lemvig have been almost perfectly protected against attacks, although their situation is the same as the other banks, only because the authorities have shown from the beginning that they were serious in their endeavours to save the banks. The information given by Justitsraad Rummelhof in his report to the Government, that 16,000 oysters (or perhaps a much larger number, as I have reason to believe) were taken at Harrevig on the two days preceding the prohibition, receives its explanation from statements collected on the spot, that the severe fishing was a result of most friendly information to the fishermen that the prohibiton was near at hand and that they must make the most of their time. The oyster fishermen therefore streamed together from all quarters, and as one of the men fishing informed me, there were over thirty boats there beside one another in Harrevig fishing up the oysters from the fjord. Another who also took part informed me that he had been fishing on the very day of prohibition, but so early, that he was able to land and sell his catch before the prohibition was proclaimed.

The prohibition however by no means prevented the oyster fishery from going on, as I have been assured; a small changein direction was the only result. The people in Nykjøbing, who had fished there gave up, but the peasants round about Harrevig etc, continued the fishery, and brought their catch in sacks for sale to Nykjøbing; as the trade there had however to be carried on with a certain amount of care and secrecy, the prices were low, and the sellers had often to be content with 2—3 marks per hundred, which led to speculation on a fairly large scale, as the merchants sent by no means small quantities to Aalborg and other places.

These reports seem to find confirmation in the large number of oysters offered for sale and consumed in Copenhagen after the prohibition. I was told also in Thisted that oysters could be obtained after the prohibition over Nykjøbing. If any attention was paid to the trade, it was a sufficient answer to bluster out that the oysters had been taken before the prohibition and kept in boxes.

5) Just as the varying views of the different persons in authority—according to some the Crown has become seriously involved in prescriptive rights, whilst in the opinion of others nothing more has been done in this direction than just what could not be avoided — have had a harmful influence on the oysters banks, as shown in the foregoing, they have also contributed in several ways to raise discontent amongst the people round the Lim Fjord who consider themselves more particularly interested in the oyster fisheries. Under the prevailing conditions it will perhaps scarcely be possible to do away with at least the worst existing irregularities in a quicker and better manner, than by at once giving over the banks to lessees, a method which seems to find support in the com-

mon wish on the Lim Fjord and which is rendered easy in certain ways by the fact that several have expressed themselves willing to take out contracts to farm the beds.

The Office of Crown Lands will thus be able probably without great difficulty to let out the Lim Fjord banks on conditions which would secure their being maintained in good condition, as the whole care for their preservation, development etc. would rest upon the lessee or lessees.

As the Office of Crown Lands must determine as to the letting out of the Lim Fjords banks, several alternatives offer themselves, all of which could perhaps be supported by plausible reasons: the banks might be let out in parcels or in one lot; they could be put up to auction, or without auction the representation already made, according to what has been reported to me, by Messrs. Claudi, Lykke and Steenberg might be agreed to. If the beds are parcelled out, a method so far as I could gather most in favour amongst the inhabitants on the Lim Fjord, and which perhaps, if regard is only taken to the momentary advantage, would give the highest return — then the part of the fjord which has to be let out could be naturally divided into four basins: Nissum-Bredning bounded at Ottesund, Venø-Bredning bounded in the north by Jegindø and Kaas, Sallingsund from Kaas to Nykjøbing and lastly the Bredning between Løgstør and Mors to Feggesund. By letting out the banks without auction to the persons mentioned, the risk is run of rousing great discontent among those who might possibly wish to undertake the contract, but would find themselves by this procedure prevented from competing. For the rest, I should imagine, after the opinions expressed by these gentlemen to me, that this procedure would be the one which gave the greatest guarantee, not only for the maintenance but also for a further development of the oyster fisheries in the Lim Ford.

As I have acted in the belief that, in case of letting out the banks, it would interest the Office of the Crown Lands to have an approximate estimate of what might fairly be considered the yearly income from the banks, I have endeavoured as far as possible to arrive at a definite impression on this point, and have constantly had it in mind throughout my investigations. As result I venture to express the opinion that the lesses could scarcely at present be able to pay a higher yearly sum than 400 Rd.*, if the banks are to be not only maintained but also worked up and increased. But just as I must everywhere concede the incompleteness of my hasty investigations, I must also in this extremely difficult point not lay any great weight on my estimate.

Even though I believe, judging from the present conditions in the Lim Fjord, that I would advise the contracting out of the banks, yet on the other hand I consider it right that the contracts should be for short periods, to begin with not longer than 3 or at most 4 years. Not merely because the value of the banks as just shown is problematic, but also because on the one hand oyster production and culture might make great advances, and on the other conflicts could easily arise between the oysters fisheries and the older lawful fisheries

* 1 Rd. = 2 Kr.

in the Lim Fjord, which would make it desirable to get the hands free as soon as possible in order to make the necessary provisions. It might also be considered to the purpose, to oblige the eventual lessees to give yearly reports on the banks and on the progress and extent of the fishery, by means of which important contributions towards a more complete and more trustworthy knowledge of the conditions could be obtained.

My lack of training in the preparation of charts does not permit me to follow out the wish of the Office to have a chart of the oyster banks in the Lim Fjord. But if the Office would kindly have a chart prepared of the western part of the Lim Fjord, on whatever scale might be considered suitable, I am very willing to mark off on it the oyster banks know to me.

6) A report on my two resultless journeys to Frederikshavn in order to take part in an inspection of the »fladstrand« banks, will be sent in later.

I enclose herewith the papers entrusted to me by the Office, concerning both the »fladstrand« and the Lim Fjord. There is likewise included a detailed statement with appendices so far as was convenient and possible of the travelling expenses: 136 Rd. 1 Mk. 7 Sk., in which the surplus of the 150 Rd. namely 13 Rd. 4 Mk. 9 Sk. is also entered.

Lastly, I beg respectfully to suggest that the allowance voted for my investigation, 50 Rd., might be forwarded to me.

Kjøbenhavn, 6th September 1852.

Most respectfully

Henrik Krøyer.

H. Krøyer's Report 1853.

After inspecting the »fladstrand« oyster banks in company with Kammerassessor, Herredsfoged Saxild, and drawn up a report as to their condition — which report makes it unnecessary to discuss the subject here — I travelled from Frederikshavn to Sundby in order to continue the journey with the S. S. »Limfjorden« to the parts of the fjord which possess oysters banks. The weather with continuous storm and rain proved however to be extremely unfavourable for their investigation. After waiting a day at Nykjøbing without being able to get at the nearest banks, I resolved for the reason mentioned to go on to Struer and Lemvig, and to put off the investigation of Harrevig until the return journey.

Although the weather continued to be on the whole unfavourable, I succeeded during a short break in the storms in investigating the Lemvig banks as sufficiently almost as was wanted. But as the weather on my return to Nykjøbing had not become any milder, I was obliged to travel by carriage to Sallingsund and from there to Harrevig, and then endeavour with a boat to make a survey of the banks.

The results which seem to me to have been obtained, in spite of the unfavourable weather, are as follows:

a) The Lim Fjords banks, and especially those at Lemvig, have suffered not a little by the past severe winter, as all the oysters in less depths than about four feet have been killed by the frost. This appears clearly from the fact that I could not obtain a single living oyster from the depths mentioned, but on the other hand a number of empty, still partly connected shells (the animals in which had thus died but a short time previously). At greater depths than four feet living oysters were found but no empty connected shells.

This damage, to which the Lim Fjord banks are always exposed owing to the natural conditions, will on the other hand be again made good by nature itself, as often as a series of milder winters occur. It is naturally the business of the contractors to see to the preservation of the oysters exposed to frost by removing them in time,

b) The banks could not in general be considered as having been too severely fished during the past winter, less so because the weather was to a considerable degree a hindrance to the prosecution of the fishery. Some banks were fished very little (at Lemvig for example), others so far as known not at all.

c) The banks in and beyond Harrevig seem however to be an exception and to a great extent to have been fished out, if I am able to rely upon the experiments made, though it has to be remembered here that the unfavourable weather as mentioned already was in high degree a hindrance to exact investigation. It will probably be to the interest of the contractors to let these banks alone in the coming winter or to fish them to but a small extent.

d) That the oysters at some places, as reported by the lessees, were covered by sand, I have not as yet been able to convince myself. The damage cannot however have been of great importance. I believe also that the oversanding in the nature of things must proceed so slowly and gradually that the exposed oysters might in one way or another be saved or protected, if attention is paid to the matter.

e) The lessees do not seem up to the present, so far as I have been able to detect, to have undertaken any work of importance either in the way of exact investigation of the Lim Fjord oyster banks or for their increase or development. The short time however, the weather and other excusable circumstances should not be forgotten in this connection. The lessees have obtained oyster dredges from Frederikshavn and are disposed to experiment with these in deeper water. How far this will be successful however seems to me somewhat doubtful.

Just as I had unfavourable weather during the investigation of the banks, other unfavourable conditions appeared on my return which made the journey somewhat longer and more costly than it would otherwise have been. I may just mention here the non-arrival of the S. S. »Cimbria« and the stoppage of the S. S. »Iri« at Aalborg in consequence of the epidemic, which circumstances obliged me to journey round by Aarhus.

Included herewith is a statement of the expenses connected with the journey.

Kjøbenhavn, 9th August 1853.

Most respectfully

Henrik Krøyer.

In the »Jutland Post«, No. 155, year 1873, some information of importance is found regarding the oyster fishery in the Lim Fjord in earlier years, in the time of the lessees Steenberg, J. C. Jørgensen, M. N. Schibbye and Kløvborg. I may cite a portion of this article though it contains several inaccuracies.

»We recognise the difficulty of giving a picture of the conditions, of which only a small portion of the public, who it may be considered will read this, can have sufficient local knowledge, as knowledge is necessary here of the earlier conditions in the Lim Fjord, especially as regards the fishery, and we therefore believe that it will not be out of the way if we first of all recall what these conditions were about a generation ago. Until 1825 the water in the western basin of the Lim Fjord was fresh, and the fishes were then the usual freshwater species which occur in our freshwater lakes; but after the break through of the North Sea at Agger in 1825, by which the fjord water became completely salt, all the earlier fish in the fjord died out, so that the banks of the fjord were covered by hundreds of loads of dead freshwater fish. Other species now gradually made their appearance, chiefly plaice and a smaller kind of cod. Oysters were detected in the forties, when some fishermen in the western part of the fjord let it be known, that they now and then took a kind of shell-fish, as they called them, in their fishing apparatus; but they did not bring them forward or laid themselves out to fish for them, as they did not know their value at that time. It was only in 1850 that the father of the present writer Steenberg, late Agent Steenberg in Nykjøbing, got notice of the matter through a fishermen bringing some oysters to Nykjøbing, and after obtaining information as to where they had been taken caused the place to be more closely investigated. He then obtained a small barrelful, which he sent to a personal acquaintance of his in Copenhagen, who stood in close connection with the Government of that time, together with information as to where they had been found. These oysters were found on the north side of Salling in Salling Sund so close to the shore, that with the water clear they could be seen from a boat and taken up with a rake. They were scattered about singly, not in beds, and as the opportunity arose he got the fjord better investigated and thus found oysters at other places, especially in Harrevig somewhat further to the west, also single scattered oysters but nowhere in beds.

»The Government now took up the matter, prohibited the oyster fishery in the fjord and in 1851 privately let out this fishery over the whole fjord for 3 years to Agent Steenberg in Nykjøbing, Kammeraad Lykke in Thisted and Justitsraad Claudi in Lemvig at a rent of 300 Rd. yearly. This contract was on running out again renewed for 3 years to the same men, and then Agent Steenberg took it over alone for 4 years until 1861. Then the contracts were auctioned for a period of 10 years and the fjord on this occasion was cut up into 5 divisions, namely: from the east as far as Løgstør (1st division), the large Livø Bredning (2nd division), the stretch through Salling Sund down to Struer (3rd division), Thisted Bredning including the stretch west of Mors to Ottesund (4th division) and Nissum Bredning from Ottesund west to Agger Canal (5th division). Of these the writer's father Steenberg rented the 2nd and 3rd divisions and the undersigned Kløvborg, Jørgensen and Schibbye the 4th and 5th divisions.

»During the first 10 years, from 1851 to 1861, when Steenberg in part

alone had the fishery, the fjord was so well investigated that where the oysters were and were not found became very well known, and the latter at the end of the period was chiefly the case in the 3rd and 5th divisions and at various places here and there. At the very end of the time oysters appeared in the neighbourhood of Fuur, whilst in the northern part of Livø Bredning and in practically the whole of the 4th division no oysters were found. Although the oyster fisheries, when the contracts were made in 1861, were known and had been carried on in the fjord for the 10 years previously, and although the contracts were then no longer made privately but by public auction, yet the importance of the fisheries was so little regarded by the people around that the whole fisheries in the 4 divisions named were let out for a sum of ca 900 Rd. yearly, which was considered sufficient as matters stood, when no one would give anything for the future uncertainty. The results of the first years showed also, that the thing was of no great pecuniary importance, as the amount earned was then only so large that we could carry on the business without being the object of envy. The Government also recognised that the fisheries had at that time no very great importance; but it had a right perception that they might possibly be helped forward in a quicker manner and on a larger scale, if the lessees could be interested in the matter, and this was reached by the Government, in the conditions, not imposing as a duty on the lessees the making of certain arrangements but offering them a distinct advantage on the expiry of the contract if they did so of their own accord. As examples of arrangements considered expedient by the Government were named, the laying down of oyster parks and artificial oyster banks, but it was added in general »or other arrangements advantageous to the advancement of the fisheries«. It was imposed upon the lessees however, that if they should make any such measures, they should make an annual report to the Government regarding what had been done and lastly the following promise was made to them in the conditions: »In so far as the lessee at the end of his contract can show that he has laid down oyster parks, artificial oyster banks or made other arrangements of advantage to the fishery, which might be considered as contributing towards the receipt of a higher rent during the next contract, he is entitled to a half portion of what the rent amounts to over what he himself has given, either paid out as one sum or in a reduction of the rent if he himself should remain the lessee.«

»Where the oysters originally came from cannot possibly be determined with certainty, but it is clear that they only arrived there after 1825; and if no weight is laid upon the fact, that a private person was induced by the then Amtmand Faye to introduce a lot of oysters in the thirties, which were laid down in Nissum Bredning in the neighbourhood of his house, then there is hardly any other probable cause for their occurrence than that the spat were carried in from the North Sea through Agger Channel into the fjord. That the oysters have no movement of their own need not be mentioned; but every one can gather therefrom that their occurrence and distribution must be due to currents in the water, which carry on the young until they can find a place where they can fix themselves and which contains the conditions for their further development. That the oysters do not require many years to grow up seems to be a fact; but it seems also true that they require many years to spread themselves over a large extent

of water, through which the current is mainly in a fixed direction. In the year 1851 fully developed oysters were found on the Salling side of Sallingsund, and some years previously, as already remarked above, it was learnt from the fishermen that there were oysters in Nissum Bredning, where in 1851 also, in the time of the first contracts, they were found to be of so unusual a size that, if one judge as to the age from the size, they must certainly have been older than those usually brought to market. We believe therefore that there is good reason to consider, that the oyster spat entered the fjord and began to spread there at least 10—15 years before the first contract began, thus 20—25 years before our contract.«

The views of the lessees that the oysters must necessarily take some years to spread themselves over the Lim Fjord from west to east, I do not share; if the oysters as spat once enter the Nissum Bredning, they will certainly spread themselves very quickly over the whole of the fjord as far as the oyster can live at all, namely somewhat to the east of Løgstør. I mention this remarkable belief in the slow spreading of the oyster as it has played an important part in the history of the Lim Fjord fisheries. On the other hand, I must naturally agree with the lessees that it was only after the breaking through of the Thyborøn Channel in 1825, that it became possible for the oysters to live in the Lim Fjord; as the Lim Fjord then became at one stroke the saltest fjord in Denmark — the only one still sufficiently salt that the oysters can live and reproduce in it.

Collin writes: »As is well known, the part of the Lim Fjord which lies west of Løgstør might be said to have been up to 1825 a complex of larger and smaller, connected freshwater lakes, which had their common outlet into the Kattegat.«

We learn from Krøyer's reports that the oysters almost as soon as they were observed occurred from the western parts of the fjord and over the whole of the area which is now fished (see Chart). Whether the few now found to the east of Løgstør had anything corresponding in those days is not known and is of no importance. It is of interest to note Krøyer's statement, that the young oysters were so numerous in the Lim Fjord, much more numerous than on the banks in the Kattegat; this agrees perfectly with my own much later observations on the present conditions.

In 1853 the lessees Steenberg, Lykke and Claudi reported, that oysters were to be found right down in Hvalpsund, at Rottholmene, Livø Tap etc., thus over great parts of Livø Bredning. It seems to have been long before the banks were found and long before it was learnt to fish them well; since even in 1856 the contractors report, that as the ice prevented the fishery in winter and »it can only be carried on in calm and clear weather« they had but few fishing days in the year. They only pole-dredged the ground and believed that the ordinary oyster dredge could not be used in the Lim Fjord on account of the many stones on the bottom. They stated that »no other oysters naturally can be fished than those lying on the bottom, or so near the shore that they can be seen in clear weather.«

The fishery in the Lim Fjord was therefore not very extensive, although there must certainly have been a rich stock of oysters in the fjord.

The Government seems to have done nothing more in the matter after getting Krøyer to investigate the banks: and it was certainly from foreign parts,

after Professor Coste had made his well-known experiments in artificial oyster culture in France, that the impulse came to take up the matter. From available documents for Nov. 23rd 1859 it appears, that on account of Krøyer's feeble health the Government could not employ him again, and as the Professor in Zoology Japetus Steenstrup was absent just at that time, the Professor of Physiology Eschricht was called upon. Eschricht readily took up the matter, journeyed to France in 1860, later to the Lim Fjord and sent in his above-cited, interesting printed reports. It was in consequence of these that the Lim Fjord in the period from 1861—71 was let out in 5 divisions, with the right to lay down oyster parks in them, and that the standard for oysters was reduced by the Government to $2^1/_2$ inches, as it was for the Schleswig and »fladstrand« banks. The lessees did not however carry this standard into effect, but fished only the 3 or even $3^1/_2$ inches and they took no advantage of their rights to lay down parks.

It has not been possible for me to ascertain whether Eschricht had anything more to do with the matter later than 1862. The fishery evidently went on as best it could during the 10 following years. The large numbers of oysters fished at the end of this period show clearly that the fishermen had now learnt how to dredge.

The next time the fishery was to be let out, ca. 1870, the Government called upon a new man to be their expert, namely, Jonas Collin: he remained the expert until 1905. In 1870 he proposed »that the standard under the new contracts should be 3″ or $3\frac{1}{2}$″«; Kontrollør Andersen proposed 3″ in diameter and it remained at that until 1893.

Appendix I gives a brief summary over the statistics concerning the contracts and the oyster fisheries in the Lim Fjord, so far as I have been able to obtain them.

As will be seen the fisheries were let out for the first time, 1852—53, for ca. 400 Rd. (App. I). After 1861—62 and till 1870—71 the rent was somewhat higher, 885 Rd. How many oysters were fished during the first period I do not know; the number can scarcely have been great. In 1860 the lessees informed Eschricht that they fished that year 150,000 specimens, but in $18\frac{67}{68}$—$\frac{68}{69}$—$\frac{69}{70}$—$\frac{70}{71}$ respectively 1,7 mill., 3,9 mill,, 4,6 mill. and 5,3 mill. were fished. After $\frac{70}{71}$ the rent rose from 875 Rd. to 42,000 Rd. The »Dansk Fiskehandelsselskab« now obtained the management (business director Kuhnert, manager Paulsen). As the rent of the contracts had risen so greatly the question was much discussed of recompense to the earlier lessees, who claimed that they had improved the fisheries in various ways and therefore according to the contract held themselves enlitled to the half portion of the increased rent. I need not enter here any further on this subject, but merely refer to the official documents (see List of the Literature »Aktstykker«).

The conditions for the »Fiskehandelsselskab« are printed in Appendix IV. The company fished during the 5 years of its contract respectively $7\frac{1}{2}$—$7\frac{1}{2}$—$7\frac{1}{3}$—$5\frac{1}{2}$ and 6 million oysters, and obviously did good business. In 1876—77 the »Handelsbank« obtained the contract, again with Kuhnert and Paulsen as directors, but the rent was now raised to 240,000 Kr. per annum to begin with. The quantities sank however from $5\frac{1}{2}$ to $3\frac{1}{2}$ to $2\frac{1}{2}$, $2\frac{3}{4}$ to $1\frac{1}{2}$, 2 to $1\frac{3}{4}$ to $1\frac{1}{3}$ to less than

one million in the last two years, and the rent to ca. 70,000 Kr. A glance at Appendix I shows the gradual decline from 1873—74 to 1885—86, a decline which clearly shows that the old, rich stock had been so severely fished that it had become noticeable [1]). This means that the stock of large oysters had become thinned out, though not to the extent that the Table seems to indicate, as in the Handelsbank's conditions (Appendix V) a paragraph (§ 3) is found which reads: »that the banks which are not able to give 1000 oysters full measure daily for a boat well provided with 4 dredges under favourable conditions, have to be rested during the whole of that season«. This regulation, which seems to have been very strictly enforced, gradually excluded the lessees from fishing over very large areas, so that they finally were unable to take the number for which payment was obligatory, namely 150,000. The Government then endeavoured to counteract this decline by a provisional closing of the oyster fisheries in the Lim Fjord from May 1885 to September 1890. This close period was only maintained however for the first four of these five years, as appears from App. I. In 1890—91 the fisheries were again let out to Tonning and Teilman-Friis for 5 years, and later to Toning alone for another 5 years (see App. VI for the conditions). In 1900—1901 the fishery was let to Brinck, Jørgen E. Mar. Jensen, Halse and G. H. Spellerberg (see App. VII), who still have it. In the years after the close period ended in 1890, the fishery never brought in more than about 1 million oysters per annum; most in 1905—06, namely 1,200,000. It cannot be said therefore that the close period had good results; since before the closure about a million were taken, and after its withdrawal about a half, though rising now evenly to 1,200,000.

What we learn from the past years regarding the artificial methods of increasing the stock of oysters in the Lim Fjord is not much. The transplantations of standard oysters in earlier years for the purpose of propagation is denied all positive value by the Government Adviser J. Collin, and certainly with right. It was Eschricht who proposed this in 1860, and it was also through his proposal that the fjord was let out in divisions with sole rights to the lessees to undertake the laying down of oyster parks. That the result was so bad and gave occasion to a law-suit for compensation was not Eschricht's fault; there is a sound principle at the bottom of the division of the fjord into many small subdivisions; on this see later.

Since 1890 various experiments were made by Tonning, most probably under the direction of Collin, at least under his inspection, at Oddesund and Nykjøbing on Mors to rear young oysters in closed basins; but these have been without result. In my opinion they were wrong in principle.

In spite of the apparently small results of the close period in the four years mentioned above, better fortune has followed the endeavour to maintain the stock than to increase it; only no profit has been made. In later years the idea has on the whole been more to preserve than to increase, and people were obviously very much afraid that the stock might be wholly destroyed. The sorrowful fate of the Schleswig banks in the North Sea perhaps contributed to this feeling.

[1]) Perhaps also the natural conditions, e. g. the hard frost in 1876—77, contributed to the decline.

There can be no doubt either that severe fishing could remove almost the whole stock in certain waters: this has happened, for example, according to information I have received from Holland, in the Zuidersee, though the latter with its smooth sandy bottom is almost everywhere adapted to dredging; the conditions in the Lim Fjord are something quite different; its at many places very uneven stony and rocky bottom (cement rock) sufficiently prevent a complete dredging out of the oysters. A combined dredging and diving system must at any rate be used here to produce the total ruin of the fishery. A diver namely might take up the oysters from the uneven places where the dredge cannot work.

Amongst the regulations from earlier times which have been of the greatest influence in preserving the stock must certainly be mentioned the standard for oysters, 3 to $3^1/_2$ inches in diameter, in combination with the regulation that a boat with 4 dredges at work must under favourable conditions be able to fish at least 1000 standard oysters per day, to permit of dredging being carried on at all on the banks in question.

The close time in the summer months, when the oysters are spawning and not of good flavour has certainiy also had some importance in this regard. The regulations that all star-fishes dredged up should be killed before casting them overboard has scarcely had any importance. In later years the principle of payment for each single oyster fished has certainly contributed to a too careful treatment of the stock. It was the raising of this rent from ca. 3 to over 6 øre per oyster, which has brought up the income from the contracts after 1890 to about the double of what it was in 1900; as the number of oysters taken has been almost the same before and after 1900 (see App. I). Whether the diving for oysters introduced since 1900 actually damages the stock less than careful dredging I must leave undecided; by dredging the banks may be cleaned, but not by diving.

Product of the Oyster Fisheries in the Lim Fjord, 1852—1906.

Year.	Lessees.	Rent.	Number of oysters fished.
1852—53	Steenberg, Claudi and Lykke.	400 Rd.	ca. 30,000
1853—54			
1854—55			
1855—56	The same.	325 Rd.	ca. 86,000
1856—57			
1857—58			
1858—59	Steenberg alone.	322 Rd.	
1859—60			
1860—61			ca. 150,000 spec.
1861—62	Div. 1: Brix.	885 Rd.	
1862—63	Div. 2 and 3: Steenberg (later his widow and sons).		
1863—64			
1864—65	Div. 4 and 5: C. Hansen,		
1865—66	Mathrar Møller, Jørgensen,		1,147,350 spec.
1866—67	Kløvborg and Schibby (the		1,207,150 —
1867—68	first 2 however soon left		1,727,100 —
1868—69	the company).		3,868,500 —
1869—70			4,620,967 —
1870—71			5,343,248 —
1871—72	Dansk Fiskehandelsselskab.	42,000 Rd.	7,519,030 —
1872—73	(Paulsen, Kuhnert).		7,511,825 —
1873—74			7,364,765 —
1874—75			5,551,155 —
1875—76			5,933,130 —
1876—77	Handelsbanken, (Paulsen,	240,000 Kr.	5,521,915 —
1877—78	Kuhnert).	240,000 —	3,555,735 —
1878—79		240,000 —	2,628,025 —
1879—80		110,000 —	2,875,130 —
1880—81		70,000 —	1,479,295 —
1881—82		111,747 —	2,075,990 —
1882—83		96,470 —	1,759,810 —
1883—84		84,000 —	1,319,465 —
1884—85			946,865 —
1885—86			(921,825) —
1886—87	Close period.		
1887—88			
1888—89			
1889—90			
1890—91	Tonning and Teilman-Friis.	17,599 Kr. 44 Øre	586,648 —
1891—92		34,855 — 67 —	774,570 —
1892—93		29,298 — 60 —	871,944 —
1893—94		26,632 — 48 —	765,299 —
1894—95		32,264 — 30 —	890,572 —
1895—96	Tonning.	32,679 — 45 —	1,007,178 —
1896—97		33,845 — 70 —	1,053,828 —
1897—98		36,614 — 12 —	1,164,565 —
1898—99		34,709 — 78 —	1,088,391 —
1899—1900		32,349 — 2 —	993,968 —
1900—01	Brinck, Jørgen E. Mar. Jen-	62,591 — 91 —	1,009,547 —
1901—02	sen, Halse and G. H. Spel-	70,256 — 60 —	1,133,171 —
1902—03	lerberg.	63,540 — 33 —	1,024,844 —
1903—04		67,702 — 8 —	1,091,969 —
1904—05		66,257 — 74 —	1,068,673 —
1905—06		72,504 — 22 —	1,238,846 —

B. Investigations of the author in 1895, 1896, 1905 and 1906 etc.

For a rapid glance over the hydrographical conditions in the Lim Fjord I may give here some measurements of the specific gravity of the water, made duringa voyage of »Havørnen« from September 4th—11th 1890:

			Temperature	Salinity in ‰
At Gjøl	was found a specific gravity of	1,0200	15,0 °C.	2,56
» Løgstør	» » » » » »	1,0210	15,0 »	2,69
» Fuur	» » » » » »	1,0215	15,5 »	2,76
In Launs Bredning	» » » » » »	1,0170	15,0 »	2,17
» Virk-Sund	» » » » » »	1,0140	15,0 »	1,78
» Skive Fjord	» » » » » »	1,0173	14,7 »	2,21
West of Fuur	» » » » » »	1,0220	15,0 »	2,82
At Ør Odde	» » » » » »	1,0230	15,0 »	2,95
In Kaas Bredning	» » » » » »	1,0238	15,5 »	3,06
North of Jegindø	» » » » » »	1,0224	15,0 »	2,87
At Kaas Head	» » » » » »	1,0236	15,5 »	3,04
East of Venø	» » » » » »	1,0238	15,0 »	3,05
At Struer	» » » » » »	1,0236	15,2 »	3,04
In Nissum Bredning	» » » » » »	1,0248	15,3 »	3,18
At Krik	» » » » » »	1,0186	15,7 »	2,39
» Lemvig	» » » » » »	1,0246	15,7 »	3,18
E. of Skibsted Fjord	» » » » » »	1,0200	15,7 »	2,58
In Visby Bredning	» » » » » »	1,0200	15,2 »	2,56
E. of Thisted Br.	» » » » » »	1,0208	15,3 »	2,66
At Nibe	» » » » » »	1,0180	14,3 »	2,33

The salinities given above are marked on the Chart accompanying this paper with exception of the last at Nibe, which falls outside the chart. It will be noticed that wherever the salinity is over 2,50 ‰ oysters are found, and none on the other hand where it is under 2,40 ‰. Thus there are none at Krik, in Launs Bredning and Skive Fjord or east of Troldholmene. The salinity was however high at Gjøl, but it must be remembered that in the narrow, eastern part of the Lim Fjord the salinity is so extremely variable, that a momentary picture cannot be considered as giving any useful guide to the conditions there. This variation can also be seen from the above figures, as at Nibe (at the outlet) only 2,33 ‰ was found 7 days after the observation of 2,56 ‰ at Gjøl. On both days the salinity was most probably the same at both places.

The salinity has thus undoubtedly a very distinct influence on the distribution of the oysters in the Lim Fjord, but it is impossible for me to state the

precise percentage required; as it is not known at all these places how the salinity varies at other periods of the year. The measurements of the salinity were made in September 1890, but in spring the water is perhaps a little fresher, and during great storms also the salinity may obviously vary somewhat at many places; I am inclined to believe however that oysters with us can scarcely live and reproduce to any considerable extent, unless the salinity as a rule and especially during the spawning time is up towards 3 %. This is indicated by the hydrographical conditions at the places where the oysters are constantly found, namely, in the northern and eastern parts of the Kattegat, as well as in the Lim Fjord.

To obtain information as to the degree of salinity the spat require in the free stage, a stage when we should expect that the salinity of the water or rather the specific gravity would have great influence, the spat were taken from as far as possible ripe oysters (thus very dark-coloured spat) and placed in several glasses containing water of a specific gravity of 1,0150, 1,0162, 1,0173, 1,0233 all at a temperature of 15—18° C. After standing for a couple of days, it appeared that almost all the fry had sunk down to the bottom in the glass with the smallest specific gravity; several were obviously dead and but very few ventured to swim freely around in the water. In the glasses with water of greater specific gravity, on the other hand, the fry continued to swim about freely for many days. We might therefore believe that a salinity of ca. 1,016 was sufficient for the spat in the free stage; but this is not definitely settled by the experiment, as I succeeded in none of the many cases where such fry were placed in glasses in getting them to fix themselves; they always died after a shorter or longer time; sometimes the fry lived for 14 days under these experiments. I may further state here that the fry can live in the free-swimming stage at a temperature of only 13° C.; this observation was made on board ship. In the open I have found the free-swimming oyster spat in water of only 15° C. At a temperature of ca. 19° C. or less they can thrive and fix themselves; thus in the first days of August 1895 the quite small spat (2– 13 mm.) were found on the collectors set out by me and on other objects present in the water. The temperature was taken each morning about 7 a. m., and during the whole of the month of July 1895 the highest temperature observed was 19,4° C. the lowest 15° C. During the same period the specific gravity in Nykjøbing Harbour, where the oyster spat was also found in July, varied between 1,02000 and 1,0239.

Temperature curves for Oddesund 1893—95 and for Nykjøbing 1895 are appended in order to give some notion of the temperature in the summer half-year.

Ripe spermatozoa with distinct tail were found for the first time in an oyster at Nykjøbing on May 24th 1895; but few were investigated. On June 14th 20 oysters from Ørodde were examined; 3 of them had white spat inside their shells, one had blue spat.

On June 15th 13 oysters over 2 inches were examined from Sallingsund, 5 of which had blue and 2 white spat. The spat was now obtained daily in our plankton net both in the harbour and in Sallingsund; it was present however in much smaller numbers than the larvæ of other molluscs. Both night and day, in bright, sunny and in dull weather the spat was found on the surface, but constantly also in deeper water; it seems to be present everywhere and at all

times, but just like all plankton in much smaller quantity where the water was shallow or filled with Zostera, and where therefore there was but little current and flow of water.

28th July: Of 39 oysters from Sallingsund and neighbourhood 2 had white and 2 blue spat.

3rd July: Very few oyster spat in the plankton at Sallingsund, but many in Nykjøbing Harbour. The currents are obviously carrying the spat some distance round the fjord. The water from the North Sea certainly contains very few of the spat. A few days later there was no oyster spat even in Sallingsund.

On the 8th—11th July oysters from various places in Sallingsund and neigbourhood were examined. Of 5 from Skælholmen 1 had blue and 1 white spat; of 16 south of Glyngøre 1 had blue spat. Of 144 pole-dredged in Faarup Vig (see Table I No. 6) only 4 had spat, none of which were quite blue; of 18 from 3—4 fathoms at Sallingsund only 1 had blue spat; of 61 pole-dredged at Studeholmene at Højriis none had spat, but small oysters down to $2^1/_2$ inches had spermatozoa with tail. Of 86 standard oysters and 150 under-sized from Trehuse at Salling (see Table I No. 8) 16 had spat, a »dwarf« of $2^1/_4$ inches had white spat; otherwise the oysters here seem but seldom to have spat before they are $2^3/_4$ inches long.

12th July: some oyster spat still in the water, even in days of windy and rainy weather, but still more of the other mollusc larvæ.

16th July: the temperature of the water has now sunk to 15° C. during a long period of westerly storms and rain, and the oyster spat is very scarce in the Sound; none at all are present in the harbour and few gastropod and mussel larvæ.

18th—19th July: warm weather again, and oyster spat appeared at once.

25th July: at Bjørndrup 74 standard oysters and 302 under-sized and young were dredged (see Table I No. 9), but only 6 had spat.

On the 26th and 27th July oysters were examined in large numbers from Brevig and Snaven at Salling (see Table I No. 2), but only 7 and 9 respectively were found to have spat.

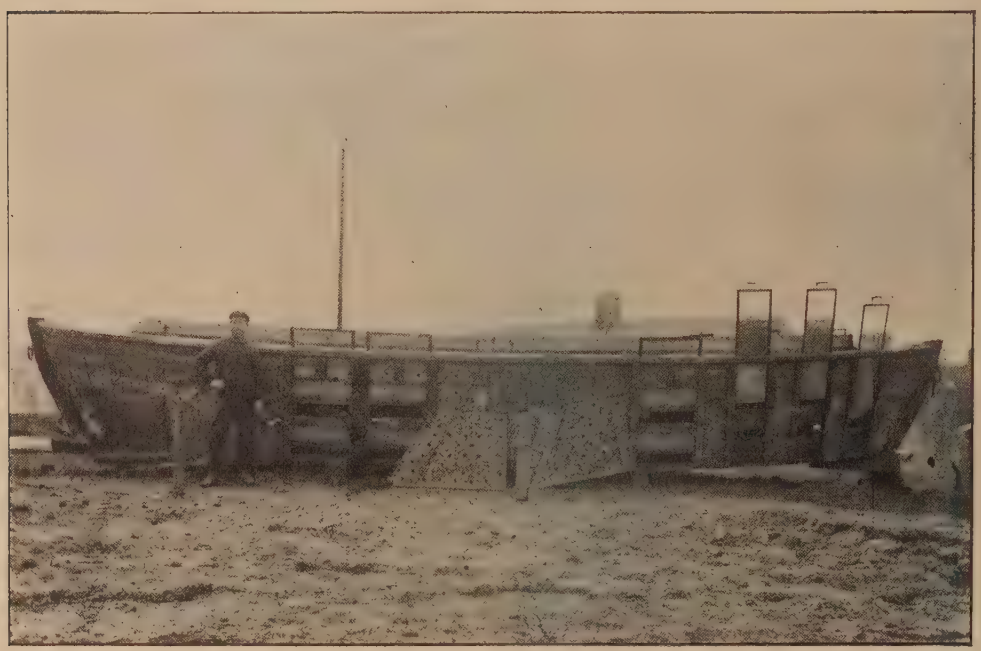
On the 31st of July and 1st of August oysters were brought up by diving in Livø Bredning (see Table I No. 11, 12 and 13), but only 3 in all had spat.

On the 3rd of August the oyster spat were observed on the collectors: some were even 13 mm. The fixing of further spat on the collectors has not been observed later.

In August the stock of oysters on the banks in Venø Bugt, at Oddesund, in Nissum-Bredning and in Sallingsund was examined (see Table Nos. 17, 15, 14, 19, 20, 16), but spat was found in but very few. In agreement with this the number of oyster spat taken in the plankton fell off in the course of the month.

The last oysters I found with spat were observed on 24th August (1895); but oyster dealers in Nykjøbing informed me that they had found a few even in September; and the spat was found in the plankton even on September 8th. Whether these stragglers are able to develop must certainly be considered as doubtful: the temperature in the water was only 13—17° and fell very quickly in the following days. I had thought beforehand that July or August would be

the main spawning time of the oyster, and the investigation of this point was therefore neglected somewhat in the beginning; but from the data we may believe that it begins a little earlier. It was also some time before I found out that we could fish the small spat in the open with sufficiently fine pelagic net of miller's gauze. Unless the period during which the spat remain within the cavity of the mother-animal is very short, it seems as if a relatively small number of oysters take part yearly in reproduction; to determine the duration of this period is obviously an exceedingly difficult matter owing to the complete closure and lack of transparency of the animal and nothing appreciable is known regarding it.



Although the weather in 1895 was scarcely favourable to the well-being of the oysters in the Lim Fjord, there was nevertheless as shown a considerable quantity of spat in the fjord, and the fixed spat was also observed both on my collectors and on other objects in the fjord: posts, boats etc.; but what surprised me most in these investigations of 1895 was, that I could not with certainty find the young of the year in quantity on the banks after the spawning time, e.g. in October. In Thisted Harbour I saw boats quite densely covered with the spat of the year; but on the Lysen (Brevig) banks (see Table I No. 3) I found no spat in October.

On Table II No. 13 the size of the spat on August 8th 1895 is represented from measurements of 24 specimens taken on the collectors; No. 14 shows the size of the same spat on September 24th 1895; a few are even already over 1 inch in length. If we remember that growth continues even somewhat late into the autumn but stops in winter, we should clearly find each spring a group of

oysters of about or under an inch in length, and in 1895 and 96 such a group was found at many places where a large number of oysters were fished on a bank (see Table II. No. 1, 2, 3 etc).

It is possible that I have missed seeing the small spat on the banks in 1895, as in later years I found them in the autumn (see e.g. Table II No. 12,

September 1896 at Bjørndrup); but the specimens were then only $^1/_4$—$^1/_2$ inch long, and it surprised me that they were so small as they were much larger on artificial objects; see e.g. Table II No. 18 for September 19th 1896, i.e. the same year in which a welled-box belonging to the Station, which had remained in the water from the spring of 1896 till then, was found to be covered by ca. 25,000 young oysters of up to $1^1/_2$ inches in length (see figures on pp. 24—25), on an average they were $^3/_4$ inch in length. On the tile collectors at Ørodde the 1895

spat were on September 24th on an average $^1/_2$ inch in length (see Table II No. 14). I can remember distinctly, and have remarked upon it, that I was surprised to find the spat much smaller on the natural banks than on the collectors and artificial objects; but this seems to be the rule. In 1905 and 1906, when I was again investigating the spat at Volstrup in the Lim Fjord in August (see Table III No. 4 and 5), I found them to be only ca. 1mm. or less. On August 1895 the spat on the collectors had already reached up to $^1/_2$ an inch in diameter (see Table II No. 13).

At Volstrup which was investigated very carefully in 1905 and 06 it was found that many more oysters of the 0-group occurred in the shallow water (3—6 feet), where we pole-dredged for the oysters, than in deeper water of 12—18 feet where we dredged. A glance at Table III will further show that the »one-year old« oysters were also more abundant in the shallow than in the deeper water.

In 1895, as mentioned, the spat were found fixed to various artificial objects, thus: on limed tiles, on spars of fir, on a wooden barrel hung overboard at the Biological Station, on pieces of granite hanging in and on the barrel, on the bottom of the boat, on the wooden piles of the harbour. The barrel, in which there was no bottom, was used to provide the aquaria on board with air; it had a small hole at the top, from which a piece of guttapercha tubing carried the air pressed out by the weight of the stones into the aquaria; when the barrel filled with water (2 times in the day), it was hoisted up a moment and new air allowed to enter below, whilst the water ran out. On August 3rd the oyster spat was observed both on the barrel itself and on the stones hanging outside and inside. Quantities of other organisms were also found here, e.g. Ciona canina, Phallusia sp., Pomatoceros, Balanus, diatoms and algæ; but it was obvious that the plants dominated on the sunny side of the barrel and stones; the green algæ were only situated on the upper parts; on the other hand the animals kept more to the shaded sides; and inside the barrel where there must have been extremely little light (only from below), many Phallusia were still fonnd and a few oysters but no plants. There is no doubt that light plays a great part during the fixing of the oyster spat; but whether the reason is that the plants quickly fix themselves on the light side and thus hinder any later fixing of the oysters, I must leave undecided. We may compare with this the experiments made at Roscoff by Lacaze-Duthiers during a number of years to get the oysters to spawn in a closed basin. The experiment seems to have been successful beyond all expectation (Archives de Zoologie experimental (3) T. 1. 1894 [1]). My experiments with collectors have only been made on a very small scale; the material which gave the best result was tiles coated with lime, which seems to be the only method now usually employed in France and Holland. In Thisted Harbour in the autumn of 1895 I observed 5 pleasure yachts, which had lain the best part of the summer in the harbour; 3 had been tarred in the spring, and the other two coated with a patent paint; on July 1st they were all cleaned and again put out, and perhaps most of the patent paint had thus been cleaned off. The bottom of these boats was much covered with various animals and plants, but some almost exclusively with oyster spat.

[1] N. et revue pg. XXV.

We notice again here that the spat had fixed itself on places where there was some shade. Just as on the barrel so here, it is on objects which are near the surface of the water and often moved by the help of man, that the spat are present in quantity; the collectors were also in shallow water and the anchoring stones especially were so hung that the waves could move them. These circumstances may be accidental, of that I know nothing with certainty.

The spat can thus fix themselves on old tarred boats; this I have observed several times; but the tar must obviously be quite dry. On patent paint on the other hand, if it is good, as it should be, the spat can scarcely fix themselves; I have not found it so in spite of good opportunities. The patent paint is indeed used everywhere just to prevent all organisms from fixing themselves to ships and thus reduce the ease with which they move through the water, and it serves what is wanted better than other stuffs; nevertheless, the algæ begin to make themselves at home in the course of some months especially where the sunlight is strong, near the surface.

As already mentioned, in 1895 I did not find the spat of the year at other places than on »artificial objects«: but I often found the spat of the previous year under »natural« conditions, e.g. in the spring (see Table I No. 4 and 5). They were found both in shallow and deep water. All the oysters of under 1 inch in length in spring could be reckoned partly to this group. If it is asked, where the oysters were fixed the answer is, that they were most frequently on oyster shells both living and dead, but also frequently on stones and other dead mollusc shells, as e.g. Tapes pullastra and decussatus, Cardium edule, Mytilus edulis, Pecten varius, further on both living and dead shells of Balanus, Pomatoceros, Buccinum undatum, Littorina littorea etc.

It is stated by certain authors that our common crab (Carcinus mænas) is one of the worst enemies of the young oysters; this however does not prevent the spat from fixing itself to the under-carapace of the crab, where the crab might easily reach it with its claws and yet does not destroy it. On the lobster we very often find a quantity of small oysters; but I have never seen an adult oyster either on living lobsters or on dead lobster shells. The skeletons do not keep long apparently after the lobster casts them off, perhaps even the lobster eats its own shell as a rule. We do not find dead lobster skeletons in the fjord; at least I have never seen any. The oyster spat can also fix itself on the hard parts of sea-weed (Fucus vesiculosus) and sometimes does so on no small scale. Oyster shells and stones are apparently the most common materials on which the oyster spat fix themselves. Of stones all sizes are used from the largest to the quite small.

The oyster does not seem very critical therefore as to the choice of its future resting place, a fact that in high degree tells upon the separate individuals later; it only seems to seek for hard objects with somewhat clean surface.

With the fixing a very dangerous period in the life of the oyster is obviously completed; but even then it is far from being safe. A number of the spat in shallow water for example will certainly be killed by the ice; a quantity will be washed on land, for example many of those fixed on the Fucus; often the spat are so crowded together that a portion must die from lack of room. Thus in the spring of 1895 I found a quantity of dead spat in shallow water and among living

oysters, the shells still hanging together, probably the young of 1894; many specimens even were still living. I am unable to say definitely whether it was the case but I believe that the frost had killed them. Many authors state in the literature on the oyster that the enemies of the oyster thin out the stock so much and it is certain that the boring snails and worms as also the boring sponges are very destructive; but of these we have only the last-named in the Lim Fjord, and they had not been the cause of death, as where they have been they leave some easily recognisable sign. I have found it very difficult on the whole, in spite of careful search, to detect the animals or plants which directly attack the oysters when fixed; in fact, apart from the boring sponges, worms (Polydora) and man, I have been quite unable to find any with certainty; on the other hand I have seen a Gammarid building its tubes of mud-particles over the shells of the young oysters and the whole of the stone on which they had fixed themselves in the well on board, and almost completely covered the oyster shells with these tubes. As every storm in the Lim Fjord stirs up the loose layers of the bottom a great deal, so that the water becomes brown with the deposited mud-particles, these Gammarids will always be able to find sufficient materials even if the oysters are fixed high above the bottom; and if the tubes are only a little advanced the mud-particles will be able to adhere of themselves, and the oysters will therefore soon be covered by quite a layer of mud. This must be a great hindrance to their growth and may at length indeed smother them completely. That the starfishes (Asterias rubens) eat oysters I have never been able to determine, in spite of eager search on the banks where there were both oysters and starfishes; it would require a large starfish in any case to eat an ordinary well-developed oyster; that they feed upon other molluscs on the other hand I have often seen, but always only those which they could quite surround and smother. It is also undoubtedly right that starfishes may be able to feed upon smaller oysters; we have direct observations on this point from Schiemenz.

There are a few species of animals in the Lim Fjord, some gastropods (Acmæa testudinalis and Chitons), which are very fond of gnawing at the upturned shell of the oyster; they do not penetrate very deep as a rule, so that they can scarcely cause any real damage to the oyster; they might even be considered as doing some good, as they therewith keep the upper shell clean from plant growths. These gastropods appear especially on hard ground; without them such plants as Fucus, violin-strings (Chorda) and the like, would certainly overgrow the oysters completely and possibly move them away from their place. These small gastropods thus play an important part in the Lim Fjord, which must be more closely investigated in the future. I have only wished to draw attention to the matter here. Possibly they destroy the very small, fixed spat.

The greatest dangers to the development of the oysters certainly do not come from the animal life in the Lim Fjord, but much more from the surrounding natural conditions and vegetation. The cold and especially the ice have already been mentioned; the latter are certainly to blame that the oysters are not found in quite shallow water in the fjord, but what obviously destroys most oysters is the mud or sand, as also at places the disturbance caused by the waves during storms. As regards the first two I have personally not seen

their effects but they are known for example to divers; these state that masses of mud will very quickly (in a few days) cover the oyster banks on which they are working, so that they are obliged to give up diving operations for a time; a storm with a different current will however soon clean the bank again, and the oysters are not necessarily dead, at least not all; the death-rate will obviously depend partly upon the thickness of the layer of mud, partly on the length of time it covers the oyster bank. Every one who has seen a storm disturb the water in the fjord, and that unfortunately there is frequent opportunity to see, will have noticed how after the storm everything under the water is covered with a layer of mud, unless the current as in the narrow courses or the action of the waves on the open coasts in shallow water again carries the layer away, from which we know that this mud may also cover the more sheltered oyster banks. Masses of sand might also cover the banks in this manner, but the fine mud is certainly the most dangerous. One circumstance comes into consideration here, however, namely that wherever a dense growth of Zostera covers the bottom, the mud accumulates there the most readily, as it comes to rest there most quickly; this circumstance along with the fact that the weed itself contributes greatly to the formation of mud on rotting away and through giving support whilst living to a quantity of small organisms whose excrement and other remains likewise turn to mud, makes the Zostera indirectly one of the greatest enemies of the oyster. The Zostera may also be destructive directly, as before it has quite rotted away it may lie in the rotting condition over the banks and thus smother the oysters. It might also be thought that other sea-weeds as well as the Zostera would be harmful to the oysters, and certain algæ may perhaps be so at places. There is unfortunately much that indicates that the above-mentioned heaping up of the mud in the Lim Fjord is increasing; certain parts of the fjord, e.g. Harrevig, are spoken of, where oysters lived earlier but where the mud and Zostera now make it difficult for the oyster to live; yet I have no fixed opinion on this matter for the time being, though it seems difficult to believe that the conditions are not as described. Heaping up of mud seems to occur also in most of our other fjords. It may be understood from this how it is possible that dredging can remove both the mud and the Zostera and again make the ground suitable for laying out oysters. That, on the other hand, dredging on an oyster bank where the conditions are good is harmful to the stock of oysters as well as to the animal life on the whole is likewise certain.

Wherever the bottom is stony without much mud and without vegetation, we should there expect to find the most favourable conditions for the success of the oysters, and this is certainly in general also the case, but there are exceptions. Dredging was carried on in August 1895 (see Table I No. 15 and 16) at Hilligsø and at Oddesund on hard ground, which consisted chiefly of stones on an average from ca. 10 to $^1/_2$ inch, but nothing else came up in the dredge. As the Table shows, extremely little spat occurred on these banks in comparison with what is found on many other banks, for example at Bjørndrup and Hanbjerg (Table I No. 9 and 14). This small quantity of spat is not characteristic of these waters as a whole, as the oyster boats belonging to Lemvig took up later a considerable quantity of spat there in the dredge, and Handbjerg with its small stock of spat

is indeed not far from Oddesund; the poverty is in fact only characteristic of strictly limited localities just with this stony ground. On closer examination of the oysters dredged up I noticed that they had been much rolled about, so that all the small cross lamellæ and sharp corners usually seen on oyster shells had been rubbed away; the whole oyster had been rounded off like a pebble; the same applies to the stones in these localities. It might happen however that an oyster had taken up a position in a hole in a stone or in the hollow of an oyster shell, which was especially the case with the few younger oysters found, and these did not have the rounded appearance but had preserved their thin corners undamaged. There is only one explanation of the phenomenon, it seems to me, namely, that it is the motion of the waves at these places exposed to the west, which is able to move and roll the stones and oysters against each other during the frequent storms in these localities. The shells in the living oysters are thus ground down not only at the edges but everywhere on the outer surfaces, and although the oysters at these places grow very thick shells (the so-called »etage-oyster« because the thickness of the shells is caused by the formation of one layer of shells after the other), in order to counteract the grinding process, they are by no means comfortable here; this is noticed especially in their soft parts; these »etage-oysters« are shunned by all oyster-eaters. The results of the gnawing of the gastropods above mentioned also perhaps help to make the shells rounded.

That the strong movements of the currents on the bottom affect the young oysters first and chiefly is clear, as they have the weakest shells and are certainly very often broken in pieces during the storms, which accounts for the small quantities of young oysters at these places. Naturally the other animals living at these places which have heavy shells also bear signs of the grinding process, and the difference is very obvious which can be seen in a collection of oysters and other shellfish dredged at such localities from another dredged at a quieter spot.

Concerning the food of the oyster, many erroneous opinions have held sway for long in the literature as well as with us. It was known certainly that the oysters must feed on quite small, almost microscopic organisms and it was concluded from this that they lived on the plankton, which is indeed exceedingly rich in the Lim Fjord. I was however much struck by the fact that I could never find the plankton forms in their stomachs, either of the plant or animal kingdom, which are so abundant in the Lim Fjord; but only quite small, green algæ or diatoms which do not belong to the plankton and usually only in small quantities; further some sand and mud particles were often found in the alimentary tract of the oysters. In a »Rapport over de oorzaken van den achteruitgang in hoedanigheid van de Zeeuwsche oester. 's-Gravenhage, 1902«, new light has been thrown on this matter. At the instigation of the Dutch Government an enquiry was made into the reasons for the decrease in the oyster fisheries at several places in Holland; extensive observations were therefore made at various places by Dr. Hoek with amongst others Dr. H. C. Redeke on the biology of the oyster. Redeke specially studied the food of the oyster and came to the surprising but most probably in the main correct result, that the oyster in Holland lived almost

exclusively on bottom-diatoms, not on planktom-diatoms; further, he sometimes found remains of copepods, larval worms, Noctiluca, Tintinnidæ and Radiolaria in the stomachs of the oysters, but the chief food was absolutely the bottom-diatoms. He found also that it was especially in the autumn and winter months that the oyster had much food in its stomach as a rule, whereas in summer during the spawning time its stomach was usually empty. I may add to this that the plankton is very scarce in the winter months, and most plentiful in the light season of the year, which agrees well with the described features of the oyster's mode of life. We can thus understand why the oyster only has a fat appearance and good flavour in autumn and winter, because it is then feeding greatly and collecting into its tissues a quantity of glycogen as a kind of reserve food. Thus, in the warm season of the year only 6—8 % of glycogen was found in the substance of the oyster, but in winter 15—20 %. The oyster spat must in any case however be said to form an exception to the rule, that the oysters feed specially in the cold season of the year, since the spat fix themselves in July—August and have already grown considerably under favourable conditions by September and October. The rules applies more especially perhaps to the oysters taking part in reproduction.

Concerning the age and growth of the oyster in the Lim Fjord various opinions have been expressed; but actual investigation of the matter seems never to have been made. Eschricht estimates the oysters of 3—4 inches to be »at least 4 years old«, probably in agreement with Agent Steenberg. These determinations of the age rest merely on guess work, as we cannot see with certainty on the older shells how old they are, and this is difficult enough on the 2—3 year old; certainly the zones of growth on the shells have something to do with growth-periods (years), but it is often not easy to determine them with certainty. I endeavoured therefore, already in 1895 and 1896 as well as in later years, partly by direct observation of the growth of the young on the collectors, partly by measuring all sizes of oysters on a bank, to determine the year-groups, as can be done often for other animals (measurement-method). The result of these observations is shown on Tables I—III. On the two first (of older oysters) the measurements are given in inches, on the third in cm.; for the sake of accuracy I have retained the original measurements partly in inches partly in cm.

The growth of the spat on the collectors can be seen from Table II, No. 13—18. In August 1895 the young oysters were on an average $^1/_4$ inch in diameter, in Sept. a little over $^1/_2$ inch; on Oct. 29th 1896 they had reached sizes between $^3/_4$ and $1^3/_4$ inches. The spat which fixed itself in the summer of 1896 on a large welled-box used for the carriage of plaice (see pp. 25 and 26), reached in Sept. the same large size between $^1/_4$ and $1^1/_2$ inches, being on an average ca. 1 inch in diameter. The young oysters on the collectors thus reached up to a little under one inch in the first year and up to ca. $1^1/_2$ the next year; but I am certain that this does not represent the normal growth of the young oysters in the fjord under ordinary conditions. The young oysters found on the banks in Sept. and Oct. 1896 (Bjørndrup and Langehage, see Table II No. 12 and 10), were namely considerably smaller, only ca. $^1/_4$ inch. These two localities last-named lie in deep water (2—3 fathoms), whilst the young oysters from all the

collectors had lived in shallow water, 1—2 feet. I must conclude that the shallow water is much better suited for the fixing and thriving of the young oysters than the deeper; and I believe we may consider it as a general rule that under otherwise favourable conditions many more of the spat are met with in shallow water than in deep in the autumn in nature. See for example Tab. III, Volstrup, where in August 1906 we obtained by pole-dredging in 3—4 feet of water a quantity of just fixed spat; dredging in 2—3 fathoms gave far fewer. Even the one-year old oysters here at Volstrup were much more numerous in shallow than in deep water (see also the other Nos. in Table). So few were the one-year old oysters in the deeper water, that I find it very difficult to consider them as sufficient for a rapid renewal of the stock.

The young of the year thus seem both more numerous and more favourably placed in the shallow water, at least till far on in the autumn, but a danger then approaches in the shape of the cold in winter, with drifting ice and ground frost, especially in the severe winters. The artificial oyster-culture in Holland is as is well-known based on these conditions. During the spawning time in summer collectors, as a rule tiles covered with lime or the like, are laid out in so shallow water that they lie dry at ebb-tide; on these the spat from the natural banks fix themselves; but before the winter comes all the collectors are taken up; the lime with the spat (ca. 1 inch or less) is scraped off, and the small oysters are placed either on banks in so deep water that they cannot be damaged by the cold, or they are kept through the winter in special ponds (hospitals) out of danger from the frost and laid out next year at suitable places where they can grow sufficiently well. The Dutch oysters are eaten when small (natives), only 3 usually 4 years old.

The question is whether a similar method would be possible in the Lim Fjord; of this see later; but one thing may at once be mentioned, namely, that there is no appreciable ebb and flood in the Lim Fjord; without further consideration it is not possible to make use of the Dutch method under our conditions. Where the work in Holland can be done by wading we must go about in boats; yet this is certainly not an insurmountable difficulty.

To obtain a view over what the measurement-method can show regarding the further growth of the oyster, Tables I—III must be more closely studied. On these Tables is represented the size of the oysters on the different banks in 4 different years. The oysters were taken partly with the dredge, partly with a pole-dredge (a kind of hand-net on a pole) by means of which the oysters can be fished on ground where the water is so clear that they can be seen. We may certainly suppose that both methods give a representation of all the sizes of oysters occurring on the banks, as the dredge especially brings up everything with it: stones, mussels large and small, and further, the small oysters which one might be afraid would fall through the iron meshes of the dredge, are fixed to larger objects so that they are also brought up. We might rather imagine that the pole-dredge selected the large oysters, as they are the easiest to see, and this is perhaps also the case; but nevertheless, as a matter of fact, the pole-dredge as a rule brings up the smaller oysters in greatest number, which must be considered

as complete proof that the small oysters are more numerous on the shallow grounds than in the deep water.

A glance at the Tables I—III shows at once, that most of the oysters taken were either large ca. $2^1/_2$—4 inches (ca. 6—10 cm.) in diameter, or quite small under or about 1 inch. We exclude here the young of the year (0-group), which in the autumn are often so extremely numerous and can then as a rule be easily separated from the older by their small size, $^1/_4$ inch or less.

In the spring we usually meet with a group of small oysters of $^1/_2$—1 inch on an average, but it is far from being so numerous as the 0-group was in the autumn, and I believe that this group consists of the young oysters of both the preceding years; these small oysters namely grow so differently that I have been unable to separate them by exact measurements. Their reduction in number is due to the death-rate caused both by the winter cold and the attacks of enemies. If we can thus not even separate the 0 and I groups longer than for a few months in the autumn, it is obviously hopeless to search after the subsequent groups 2 and 3 etc. The remarkable minimum at ca. 2 inches (or ca. 4—5 cm.), found in almost all the measurements, may probably have its explanation in that many small oysters die, and those at ca. 2 inches grow so quickly that they soon join on to the adult group (6—10 cm.). This minimum does not move either in the course of the year (see Tab. III), but may be different on different banks, according as the oysters are larger or smaller on an average. Thus, it is higher in the large oysters dredged at Volstrup (see Table III) than in those pole-dredged there in the neighbourhood (Table III). Concerning the age and growth of the oyster the measurement method can therefore only show, that an oyster of ca. 6—7 cm. is as a rule 3 summers old, and that the oyster begins to grow more slowly in length at 6—7 cm. This is of the greatest importance in the determination of the minimum standard size, concerning which more mention will be made later.

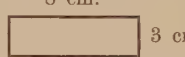
By marking oysters, if we could only find a practical method, we might be able to follow the growth at the different places and under different conditions with great exactness; this must be tested in the future. If it should be done, it would certainly prove that the oysters grow very variously under different conditions, thus for example in the youngest group (0-group) according as it is fixed on collectors in shallow water or on the deeper banks.

That the oysters when older do not become very large in shallow water, is shown distinctly in Table III, where all the oysters pole-dredged from April 1906 to August of the same year have apparently not grown in the least: most of the adult group are at 7—8 cm. the whole time, and in the previous year 1905 (see the Table No. 4) they had quite the same size; but unfortunately there was but little fishing in 1905. These pole-dredged oysters are almost all under-sized according to the present conditions of the contracts, as the rectangular standard now used of 8 cm. in breadth and. 3 cm. in height permits all flat oysters of 8 cm., to pass through as undersized and even many at 9 cm.; only 25 of all the pole-dredged oysters (those at 10 cm.) are therefore certain to be considered as standard oysters. It appears as if these oysters in the shallow water (3—4—5 feet) never become standards, and they are so situated that a severe winter, it is to be feared, will kill them, if they do not die earlier from old age or

other cause. There are many thousands of these small, exceedingly well-flavoured oysters at just as dangerous places in the Lim Fjord; on this see Krøyer's report.[1]

Table III likewise shows a number of measurements of oysters dredged at Volstrup, just beyond where the others were taken with the pole-dredge, in 2—3 fathoms but at a distance of about a hundred yards. These also do not seem to have grown appreciably from the spring to autumn 1906 nor from 1905 to 1906; but many of them are however over 9 cm. in length and a large number are up to the present standard; whether all could grow so large is a question I do not venture to answer. The largest I have dredged and represented in the Tables were ca. $5^1/_2$ inches (14 cm.). Although the oysters may be much larger in the Lim Fjord, it is not normal; many oysters certainly never grow larger than 3—4—5 inches, even if allowed to live as long as they can; this is well-known among the experts of the Lim Fjord, and was just the reason why the rectangular standard was introduced; as it prevents the old and thick oysters from passing through, even though not 3 inches broad. In so far the introduction of this standard was a great improvement on the earlier methods (ring standard). We have however certainly not gone far enough in the direction of reducing the standard and of using all that may be used.

The measurements on Tables I and II indicate that the oysters of the Lim Fjord only with difficulty reach over 3—$3^1/_2$ inches in length, since the maximum of the adult falls there as a rule. Whether this is a consequence of the fishery just permitting the oysters to be taken down to this size, or whether it is because the oysters as a rule hardly grow over this size on the banks, is difficult to say; but so much is certain, that not all oysters can reach such a size, and that the limit ($3^1/_2$ inches) is generally represented by comparatively old and slowly growing oysters. Why should we retain this considerable size? At most other places in the world much smaller oysters are eaten. One might think that the reason was, to be sure of keeping so many large oysters that the stock would certainly be preserved, and this idea has also perhaps been the reason for the retention of the standard in recent years; but the oysters reproduce right down at a length of $2^1/_2$ and $2^1/_4$ inches long, and further it would be much better for the preservation of the stock, if, provided that only a certain number of millions had to be fished, a number of these millions were from among the young oysters, as all the more large oysters would remain behind and the

[1] Note. The measurements of oysters given in Tables I—III are made across the oyster from the umbilicus down to the opposite corner; this was necessary in order to obtain comparable data. It is often however not the largest dimension; sometimes they are broad sometimes long. These measurements are therefore not directly comparable with the rectangular standard now in force 

; as the oysters slip through this sometimes longways sometimes broadways according as they are short or broad, and if placed obliquely in the rectangle oysters of ca. $8^1/_2$ cm. can pass through, especially if the fine corners are rubbed off. Since further the oysters are here always measured at their shortest part, sometimes longways sometimes crossways, this standard by no means makes all oysters from $8^1/_2$ cm. and less which are included in the Table under-sized, but it has appeared from practical trials that many oysters in the Tables of 9 cm. would be taken as under-sized. Before new standard apparatus is introduced into practice, exact investigation of its practical applicability should be made.

larger give the most spat. If on the other hand all the oysters down to 2 inches in length were allowed to be taken, certainly the stock would soon be destroyed, but there would be all the same many millions to be taken in the year for a number of years, and of this there can be absolutely no question. The standard has as mentioned certainly been retained in recent years to make sure of sufficient spawning oysters, whereas the standard under our conditions need only be fixed in order to prevent the unsaleable oysters from being brought on land or destroyed. It is in fact the question between the »reproduction theory« and »growth theory«, the latter of which has now triumphed for example in the matter of the plaice, which now concerns the oyster.

The lessees in the Lim Fjord are on the other hand interested in taking as large oysters as possible, especially as the State is paid for each single oyster, perhaps also because the fishermen receive payment from the lessees per 1000; the large would naturally meet the higher tax per specimen better than the small; but it is for the lessees to arrange this matter. The State on the other hand should take care that the stock is so exploited that it gives a large harvest each year and not as at present a small harvest with large prices. To let the oysters lie and die of old age helps neither the State nor the public, nor the large fishing population which has almost nothing to do with the fishery of these shell fish.

In 1886 the State stopped the oyster fishery because it could not yield each day 1000 oysters over 3 inches per boat with 4 dredges under favourable conditions; but what are favourable conditions? An oyster bank may be covered with sea-weed or fine mud for some time, so that no dredging can be done; a storm may then change the whole, so that many oysters can be dredged on the same bank the day after. Why stop just at 1000 oysters of 3 inches per day? From olden times $2^1/_2$ inches was the standard for oysters on the Schleswig and »fladstrand« banks; for some reason or another this was raised to 3 inches in the Lim Fjord in 1852 and for some later contracts; but in 1860 probably on the recommendation of Eschricht the Government reduced it to $2^1/_2$ inches. But this standard was not used by the lessees, they retained the old 3 to $3^1/_2$ inches. It was thus the contractors who endeavoured to keep up the standard, and in the later years since 1870 Collin has also kept this high standard. Any real reason why just $2^1/_2$ or 3 or $3^1/_2$ inches should be chosen, I have never been able to find, and it is indeed a very essential point, as just at this size we are near to the limit which many oysters cannot reach.

In his Report of 1852 Krøyer states that the Lim Fjord oysters are not so good to eat as the »fladstrand«; they are »insipid and sweet to the taste« the consumers complained, and Eschricht in 1860 says that the oysters from the Lim Fjord are of a »sweet insipid taste«, but he adds (p. 69), that he knew quite well that oysters taste differently at different seasons and especially are not good in summer (August); it was just in this month that both he and Krøyer tasted them. But Eschricht also judges from the circumstance, that the Lim Fjord oysters are so flat in the shell and therefore that they must be thin, and states that only the large oysters come into trade from the Lim Fjord, because the dealers »wished to conceal the slight thickness and fat by the larger circumference«. Eschricht saw very well that the trade preferred to deal with oysters which were »far over

»under-sized« oysters, $3^3/_4$—4 inches or more and certainly 5—6 or 7—8 years old«. It will be remembered that it was just under his régime that the Government reduced the standard from 3 to $2^1/_2$ inches; and it was he who proposed the introduction of quite a new race of oysters into the Lim Fjord. To these older statements regarding the quality of the oysters I shall only remark, either that the judgment must have been wrong, just because they were only tested in the summer, or that the oysters have improved since then; the quality now is good except in one or two years and naturally in the summer, and then the quality is not good both of the large and the somewhat smaller. The fjord cannot always offer such good oysters as the best Dutch, and the dark gills especially are a drawback for many; but that there should be a difference in quality in the oysters from the Lim Fjord, when 3 or $2^3/_4$ inches, I refuse to admit; it is in any case a matter of taste, and if both kinds could find buyers — that is the main thing. I believe that it is in these small matters of taste, that we must seek for the reasons for the high standard and not in a concern for the preservation of the stock, and it was in my opinion therefore doubly unfortunate, that the fishery was completely stopped in 1886 from a fear of overfishing; there was in reality no danger of this, and we did not learn how great a production of the smaller, but saleable oysters the fjord was capable of. For every cm. the standard is reduced from the present 8—9 cm., the fjord will perhaps be able to give just as many times as large an output. I would repeat, that the Government in 1860 endeavoured to act upon this principle; to have departed from it is unfortunate. A reduction of the standard from 8 to 7 cm. would be of great importance for the production; and with this we might well be content for the time being; results would not fail to appear, so extremely little is required here in the matter of the average size of the oysters. If the fishery had at that time been completely stopped on some good banks, e.g. on $^1/_{10}$th of the area, distributed throughout the whole of the fjord, so that they might have served as reserve or culture banks from which the spat could have been obtained for the whole of the fjord, whilst dredging was permitted on all the other banks without any standard size for the oysters, then we should now know more than we do of what the fjord can produce in the way of young, rapidly growing oysters. Here »closed waters« would have been of use, since the oysters really spawn in them — on the other hand fishes as a rule do not!

Under the remarks to a proposed law draughted by the Government for a temporary closure of the oyster fishery in the Lim Fjord (»Ordentl. Samling« 1885), we find: »It was thus not known whether »too much dredging« or »unknown causes« had led to the decrease«. But something would have been known if the proposed »experimental closure of the banks in certain large areas of the fjord« had only been carried out; since if many oysters had been taken on the closed but not on the dredged banks, then the »unknown causes« would have been eliminated; if on the other hand the stock became reduced everywhere, it would then have been shown that the closure was of no use. But complete closure was enforced for 4 years, with the result that after its termination no more oysters were fished than before the closure; within recent years however some few hundred thousands more have been fished (see Appendix I p. 20). We thus do not know

either whether the closure has been of use to the large oysters; the people at least have gained no advantage thereby, and the amount received by the State is almost the same as when the closure was imposed. To this poor result the German import duty has naturally contributed as we were thus excluded from competition, having no counteracting duty, and a considerable quantity of cheap young foreign oysters are now imported. Denmark should at least endeavour to supply itself with oysters, rather than let them perish in the Lim Fjord; even if it is impossible to say how much the fjord can continue to give in the year it is my belief based on personal observation that it can give much more than it now does, and endeavours should therefore be directed in future to fish up more oysters than is now done. This is not the place to discuss in detail how this should be arranged, but the points of view which form the basis for the present contracts are wrong. The main thing muat be to get as many oysters taken as the fjord will at all allow, without any regard for the price they obtain per oysters; in this way both the public and the State will be best served. The fjord is too large to be merely the basis of a small business for some relatively few private persons and fishermen.

If I believe that I can see more clearly into these matters than those who have hitherto had to do with the administration of this matter, this is inded quite natural, as I have my earlier experience to build upon, also because more is now known of the biology of these animals than was known 10 years ago, but in great part also because I have been personally interested in this and related matters since 1883 and have obtained means from the State in order to study them in nature. It should be understood therefore that I do not lay it to any one's charge that we are so far behind in this matter; but it has been expensive both for the State and for the oyster-eating public that careful biological investigations were not made here much earlier. It was only after my appointment as Adviser to the Department in 1905 that I became aware how much was to be done. It is certain that many years will yet go by before we learn to use rightly the valuable asset, which came to us when the Thyborøn canal was broken through and which the modern sand-dredgers annually contribute to ensure.

It has often been maintained that oysters are only a luxury, and it did not matter whether they were dear or not; but in several other lands the oysters are no luxury and if they need not be here so much the greater advantage for us; the main thing is only, that the State must obtain more profit from a more intensive fishery and that all the oysters which could be produced should be brought upon the market, so that the price is determined accordingly; in this way also the public is best served.

Since I have advised in the foregoing a more intensive fishing in the Lim Fjord, it might well be thought that artificial culture could be employed to help out or to support the production, as is done in most other lands. All that has been done in this regard in our country has come to nothing; I do not mean here the regulations for preservation of the stock or the 3 and $3^1/_2$ inches standard size and the like, but what has been done directly to increase the production, such as transplanting of oysters, laying down of oyster ponds etc.; these have all been without result at any rate at the present time. In my opinion

the reason for this is certainly to be sought for in the erroneous principles which formed the basis for the undertakings. As mentioned above, Eschricht advised the introduction of foreign oysters, but this was certainly never done by the State; on the other hand, I have been informed by a man by word of mouth that he much later placed some foreign oysters in the fjord, namely Arcachon oysters ca. 10,000, and even American »blue-points«; but most of them died, he said. I believe that even if other European races had been introduced, they would all in the next or within a few generations be converted to Lim Fjord oysters; just as the conditions now transform the oysters there. Further it was indeed foreign oysters which entered the Lim Fjord, either through the Thyborøn canal as spat from the North Sea or perhaps from the oysters planted out by Amtmand Faye. Eschricht who had been in France when Professor Coste began his experiments in laying out oyster beds, was obviously much influenced by the ideas of the latter. As is known Coste's experiments proved to be failures in several ways. But the idea of forming new oyster banks lived long in Denmark. It was the basis for the later much disputed transplantation of standard oysters in the Lim Fjord and for a »law on the oyster fishery and oyster culture« by which the Finance Minister was empowered to offer a »grant in aid of experiments with the oyster fishery, such as transplantation of oysters and laying down of artificial oyster banks and oyster parks at such places in Danish sea-territory, where the oyster fishery had not previously been carried on etc.«. Many fruitless experiments were then made right down to Lolland; some of the best known were those conducted by G. Winther in Aarhus Bay. All were absolute failures and Winther judged very rightly that the reason lay not in the bottom conditions but in the conditions as regards salt and temperature. This great belief in the possibility of being able to form new banks, not only in our county but also in Germany, was based on the fact that old oyster shells were found on most of our coasts and it was known that oysters had come into the Lim Fjord; it was naturally thought that the earlier banks had been destroyed by over-fishing and that they could now be easily renewed. How completely wrong this view was, was shown first by the author in 1888; I showed that the hydrographical conditions had changed in our waters within the Skaw since the »kitchen midden« period, so that not only the oyster but a series of other forms had died out there since the stone age, as they could no longer live under the changed conditions. The scattered occurrence of oysters in certain parts of the Kattegat may be considered as an oft repeated experiment on the part of nature to plant the spat coming from the North Sea in the Kattegat again; but it proves that banks can never be formed under the present conditions. With this explanation of mine we enter upon a new and more correct way of thinking, namely, that nature itself does all that is possible to bring the oysters to new banks by the distribution of the spat, which is carried many miles by the currents, and therefore that the oyster is found everywhere where it can live. If we would lay down oyster beds we have only to change the conditions and the oysters would come of themselves. In this way they came into the Lim Fjord when the conditions changed, and they have in spite of all statements to the contrary certainly spread themselves over the whole fjord very quickly; only it took some time to observe them, and it also took some time per-

haps before they became abundant at all places. Starting from these new principles we see that all removal of adult oysters »for transplantation« in the Lim Fjord is meaningless. Nature can well look after the spat itself and the Lim Fjord is swarming with these when the temperature is suitable. For the same reason the formation of ponds for adult oysters in the Lim Fjord is superfluous, so long namely as the oysters spawn in millions in the fjord. The serious qustion here is to help more of the immeasureably great quantities of the spat to become full-grown oysters than now happens; since obviously by far the greatest part of the spat and of the just fixed young oysters perish, because they fix themselves on unsuitable places, are sought after by so many different enemies etc. It is so much the more advisable to aim at this, since it is perhaps not every year that the temperature in the Lim Fjord is sufficiently high to permit of the oysters spawning in large quantities; if a more intense fishery is agreed upon this must be carefully watched. Further, it is far from being the whole area the adult oysters can live in which is specially suited to the production and further development of the small fry. As mentioned before it seems to be especially the warm shallow waters which are suited in summer for the welfare of the fry. Here some preliminary experiments should be made, only on a somewhat greater scale than I have hitherto experimented, to take the spat on collectors and bed them out before the winter on closed areas in deeper water and study their further fate and thus the possibility on the one hand, of recruiting on a large scale the stock of the fjord if such should be necessary, and on the other, of experimenting whether certain banks could be used for a more rapid growth of the young oysters. Such experiments would cause little expense and if successful and thereupon carried out on a larger scale would be remunerative. They might also perhaps be made by private owners on their own small banks just as is done in Holland, amongst other countries. I shall not enter into the details of the arrangement of this matter either; what I wish to do in the first instance is to bring the whole matter of the oyster fisheries in the Lim Fjord into the full light of the new experiences both scientific and historical which are now available.

What may in time be obtained from the Lim Fjord oyster fisheries if the right methods are introduced, no one can say; but in Holland ca. 25 millions of oysters are obtained yearly from areas which are only ca. $^1/_5$th of the area of our banks. I may warn against believing that we can reach up to numbers such as these; but it is indeed a long spring from 1 million oysters to 25 millions on an area of one-fifth the extent.

The Future.

The oyster fishery in Denmark has always been considered as crown property, and the Government has therefore had the free disposal of its exploitation, has it in fact even now. The State should therefore obtain some good return yearly, the size of which is determined partly by the foreign oyster market, the existing import duties, the pleasure and pocket of the public and the productivity of the Lim Fjord. Of these 4 factors the foreign market is to a certain extent of

no influence; only ignorance of its low prices seems to play any great part on our market; this state of affairs might easily be altered. To favour our market practically nothing has been done from the Danish side in the way of duties. The desire to purchase on the part of the public has been reduced considerably since the seventies; the extremely high prices of our home oysters, which with the help of the middlemen also influence the price of the originally cheap, foreign oysters, have broken off the general public from eating oysters. In earlier times when the oysters were bought for about a penny each the oyster-eating public was much larger and there were then oyster cellars in Copenhagen. Now but few people eat oysters and for these money is of no consequence; the price is now at least $2^1/_2$d each. The result is that but few oysters are eaten or fished. The productivity of the Lim Fjord is not utilized to anything like the extent it could and should be. I shall here leave out of consideration the import duties and the foreign market, as I believe that at the present they are by no means so important for us as the two other conditions, the desire to purchase on the part of the public and the exploitation of the stock of oysters in the Lim Fjord; both of these should be increased and in this way the State would gain and be certain of holding its own against all foreign competition. One result of a more intensive fishery would be cheaper prices owing to the larger numbers of oysters on the market, but the total value would only be increased if at the same time the desire to purchase increased. Whether this will increase quickly or slowly is not easy to determine, and it will therefore not be possible for a contractor to be so certain of his tender in the first years as later, when the matter has again come into order, and it is therefore a question whether the State should not itself in the first years undertake to carry on the oyster fishery even for some years after the present compact runs out in 1910. The State takes some risk in doing so, but no one is in a better position to do so; and the State would thus win experience both with regard to the right size of oysters that should be fished, and of the numbers that might be obtained yearly. The State has always the freedom namely to make experiments without binding itself to any agreement for a number of years, as the contractors must do. If the fishery paid better than now the State would naturally reap the advantage; but the most important matter is that we should in this way obtain a solid basis of knowledge for the judgment of the matter. My plan would be that the State should have small steam-boats, such as are used in Holland for this purpose, which could dredge up the oysters especially in the autumn so long as there was open water, and either at once or gradually get the stock in hand sold by auction at the Lim Fjord and in Copenhagen. Motor boats might also be used perhaps in the shallower waters and pole-dredging might be carried on on as large a scale as possible. Lastly, experiments might easily be made in transplanting oysters from shallow to deep water and on the whole experiments for a rational increase of the stock; if the State will not make the first of these experiments, they will scarcely ever be made; that at least may be learnt from the previous history.

If however the decision is made to let out the fisheries again, then there is no doubt that the method of payment for each single oyster taken (now over 3 farthings) must be given up; a sum should be given for permission to fish for

example 4 million oysters of over ca. 7 cm. yearly, but with the obligation of fishing at least 3 millions. I do not doubt that the State would in this way obtain a better yearly return in money than it now does, and it is quite possible that the oyster would also become a cheaper and commoner article of food than at present; but the contractor could not be compelled to sell the 3 millions; and he would not do it if it paid him better to sell 2 millions at a higher price. Even to bind themselves to fish 3 millions would have a deterrent influence on people who did not know the fjord, but we have seen how in the earlier contracts the lessees engaged themselves to fish 1 million of large oysters of 8—9 cm. (1875), so that this was scarcely any great hindrance. The mischief involved in contracts now is as mentioned the impossibility of determining beforehand with accuracy, when the desire to purchase oysters can be again roused on the part of the general public and to what an extent this will happen; and the contracts must run for a fairly long period, ca. 5 years; it will be difficult to obtain good contract prices for a shorter period. It might perhaps be possible to combine the two systems, since the fjord is far too large to be fished intensively and thoroughly by one man unless he has abundant means at his disposal. But if the State took charge of the fisheries in certain parts of the fjord and let out other parts, it would then still remain master of the market to a certain extent and be able to judge for itself. It is hardly possible that any great remuneration will be gained in the beginning by such a method; the contract might however advisably be extended over a number of years and would thus give a lessee an opportunity for and interest in carrying on a rational fishery. Experiments in this direction should under all circumstances be made for small areas; the only difficulty is to obtain qualified persons for the work. In this way we should approach to the method of fishing in foreign countries: a number of small parcels or lots in private hands and a very intensive fishery. We should then also learn gradually what regions were best suited to the fishing by the State with steamboats and dredges and those suited for the smaller private method of fishing. The State should provisionally chiefly regulate the import to the market and be responsible for the sufficient preservation of the stock. If men with sufficient experience and means should appear in the course of the next 3 years before the present contracts run out, it would be a great boon for the future of our oyster fisheries; we could then always discuss what methods of fishing it would be advantageous to follow.

Explanation to the Chart of the Lim Fjord Oyster Banks.

1907.

The places marked in black indicate where so many oysters are to be found that it would pay to dredge for them, or where they have been in quantities to attract notice; scattered oysters are to be found everywhere between these so-called »banks«. I may however remark that practically no oysters are to be found in the most western part of Nissum Bredning, nor in the north-eastern part of Løgstør Bredning, the reason being assuredly that the sand bottom here is too movable and barren. The reason why they are not found outside the sand bottom in the north-eastern part of Løgstør Bredning is perhaps that the vegetation here, especially of Zostera, is so rich; for the same reason but few oysters occur in the waters between Jegindø and Visby Bredning's southern portion; further in Louns Bredning and Skive Fjord the salinity is too low for oysters; this applies also to the narrow eastern Lim Fjord, east of Troldholmen, which is therefore omitted from the Chart. With these exceptions oyster banks are to be found everywhere in the Lim Fjord along the beach in the neighbourhood of »Skaaret«; they are present close in to the land in 2--3 feet of water and they go out to deeper water of 3—4 fathoms, but as a rule they do not go far from the 3-fathoms line. This is at once evident from observation of the Chart. The reason for this certainly is that out on the true deep clay beds, which form the bottom of the Lim Fjord, the ground is too soft and the clay or mud too shifting for the oysters. As exceptions to this rule may be mentioned the large banks to the west in Nissum Bredning, to the north-east in Thisted Bredning and in the north-west of Løgstør Bredning. The bottom must be of a special nature here to make it possible for the oysters to live at these deep levels.

Table I. 1895.

Measurements of Oysters, in inches.

• indicates oyster with spat

No. 1. Entrance to Lysen. 25. May.	No. 2. Entrance to Lysen. 26. July. Soft ground with stones 2–4 fathoms.	No. 3. Entrance to Lysen. 15. October.	No. 4. Refshammer Pole-dredge. 12. May	No. 5. Sebygaards Hage Pole-dredge. 16. May.	No. 6. Faarup Vig. Pole-dredge 8. July.	No. 7. Studeholmen Pole-dredged. 8. July.
5 inches						
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	ooo	ooo	o		••	oooo
	•oooooooo	ooo			•o	
4 oo	oooooooo	oooooooooooo	ooooooooooooo		•ooooo	ooooooo
oo	ooooooooooooo		ooooooooooooooooooo	ooo	••oooooooooo	oo
ooooo	•ooooooooooooooooooo		oooooooo	oooooo	•••••••••	ooooooooooooooo
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3 ooooooo	•ooooooooooooooooooooooooooo		ooooooo		ooooooooooooo	ooo
ooooooo	oooooooooooooooooooooooooo				oooooooooo	oo
ooooo	••oooooooooooooo	ooooooooooooo			ooooooo	ooo
	••oooooooooooooo	ooooooooooo			ooooo	o
2 o	ooooooooo				oooo	ooo
ooo	ooooooo	ooooooooo			ooooooooooo	o
oo	ooooooooo	ooooooooooo			ooooooooo	ooo
ooo	oooooooooooo				ooooooo	oo
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	oo	oo	oooooooo		o	oo
0			ooooooooo	1 ooooooo		

No. 8. Trehuse. 10. July.	No. 9. Bjørndrup. 25. July.	No. 10. Snaven on hard ground from 2–4 fath 26.–27. July Not diving at that time.	No. 11. Feggeklit 31. July Soft ground Diving	No. 12. Feggeklit 31. July Hard ground Diving.	No. 13. Skidenholm East of Ejerslev Ron 1. August
5 inches o	•	o			
ooo	oo one at 5¼"	o			
••	oooooo	ooo		oo	
•ooo	ooooo	oooo			oo
4 •oooooooooooooooooo	•ooooooo	••oooooooooooooooooo	oo	ooo	oo
••oooooooooooo	oooooooooooooooooo	••oooooooooooooo	ooo	•ooooooooo	ooo
••ooooooooooooooooo	••ooooooooooooo	••		•oooooooooooooooo	•oooooo
	•ooo	•ooooooooo		ooooooo	ooooooo
3 •••oooooooooooooooooooo	oooooooooooooooooooooooooooo	••			ooooooooooooooooo
••••oooooooooooooooooo	oooooooooooooooooooo	ooooooooooooooo		ooooooooooooo	oooooooooooo
ooooooooooo	•ooooooooooooo	ooooooooooooooo		ooooooooo	ooooooo
•	ooooooooooo	oooooooo		ooooooooooo	oooooo
2 oooooooo	ooooooooooooooo	oo		ooooooooooooo	ooooooo
oooooo	ooooooooooooooooooo	ooo		ooooooo	ooooooo
ooooooooo	oooooooooooooooooooo	oooo		o	oooooo
ooooooooo	ooooooooooooooooooooooooooo	ooo		ooo	ooooo
1 ooooooooo	oooooooooooooooooooooo	ooo	ooooo	ooo	o
oooooooooo	ooooooooooooooooooooooooooooooo	o		oooooo	ooooo
ooooooooooo	oooooooooooooooooooooooooooooooo	oo		ooooooo	oooooooooo
ooooo	o			o	o
0					

No. 14. Hanbjerg. 6. August.	No. 15. Hilligsø Banks. 15. August. Hard ground.	No. 16 Oddesund. 14. August. Hard ground.	No. 17. Sallingsund. 24. August	No. 18. Kaas Hoved and Nygaards Hage 28. July	No. 19. Nissum Bredning. South of Oddesund. 5. and 6. August	No. 20. Nissum Bredning. North of Oddesund 5. and 6. August
5 inches oo	o		o	oo	o	o
o	o 1 at 5¼"		o	oo 1 at 5¼"		oo
ooo	ooo 1 at 5¼"		oo	ooooooo		oooo
oo	oooooooooo	o	o	•ooo		oooo
4 ooooooo	ooooooooooooo		ooooooo	•	ooooo	•ooooo
oooooooo	•ooooooooo	oo	ooooooo	ooooooooo	ooooo	ooooo
•ooooooooooo	ooooooooooo		oooooooooo	ooooooo	ooooo	ooooo
ooooooooooo	oooo		ooooooooo	ooo	o	o
3 •ooooooooooooooooo	ooo	oo	•ooooooooooo	ooooo	oooo	
ooooooooo	o	o	ooooooo	oo		oo
ooooooo			ooo			
ooooo	o		oo	o		
2 ooooooooo			ooooooo	ooo		
oooooooo		o	ooooo	ooo	o	
ooooooooo	o		oo	oooo		
oooooooooooo	o		ooo	ooooooooo	oo	
1 ooooooooooooooooooooooooo	ooo	o	oooooo	ooooooooo	ooooo	
oooooooooooooooooooooooooooo	o	oo	ooooooo	ooooooo	ooooo	oooo
ooooooooooooooooooooo	o	o	oo	ooooo	oo	oo
oooo				oo		o
0						

Table II. 1895–96.

Measurements of Oysters in inches.

• indicates oysters with spat. O and I indicate the year groups.

No. 1. Refshammer. Dredge. 22. January 1896.

No. 2. Faarupvig. Dredge. 25. January 1896.

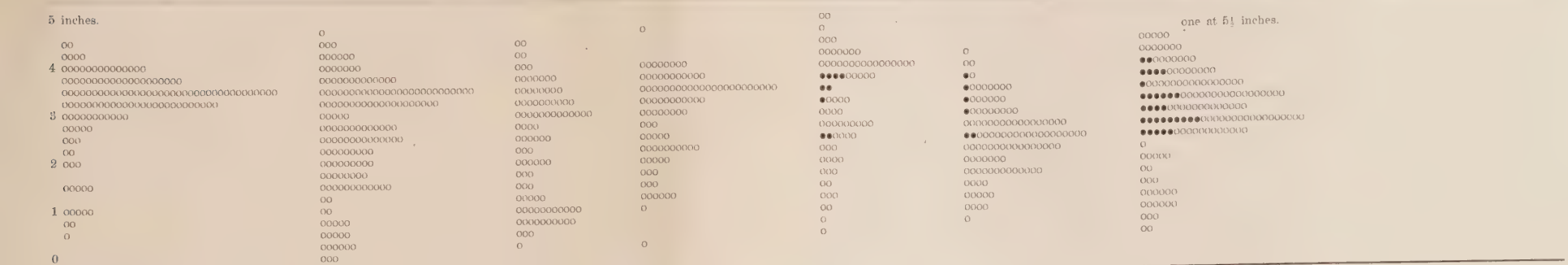
No. 3. Ravnedybet. Dredge. 4. May 1896.

No. 4. Sallingsund. Pole-dredge. 23. May 1896.

No. 5. Oddesund Syd. Dredge. 7. June 1896.

No. 6. Sallingsund. South of Højriis. Pole-dredge 16. June 1896.

No. 7. Hanbjerg. Dredge. 12. June 1896. 2 – 3 F.



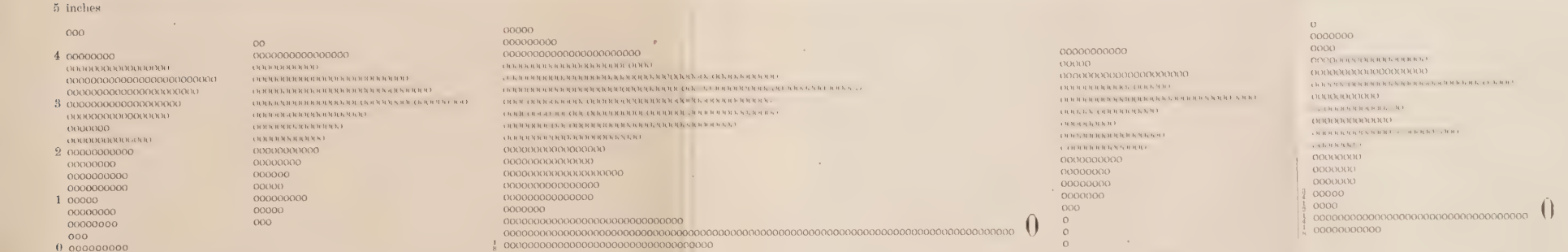
No. 8. Langehage. Dredge. 8. April 1896.

No. 9 Langehage. Dredge. 1. August 1896.

No. 10. Langehage. Dredge. 19. October 1896.

No. 11. Bjørndrup. Dredge. 27. –29. May 1896.

No. 12. Bjørndrup Dredge. 18. September 1896.



No. 13. Spat on our collectors. 8. August 1895.

No. 14. Ørodde. Spat on tiles. 24. September 1895.

No. 15. Spat on granite stones in well from summer of 1895. 8. April 1896.

No. 16. Spat from 1895 on granite stones in well. 29. October 1896.

No. 17. Spat on sandstones in well from summer of 1895 8. April 1896.

No. 18. Spat on welled box. 19. September 1896.

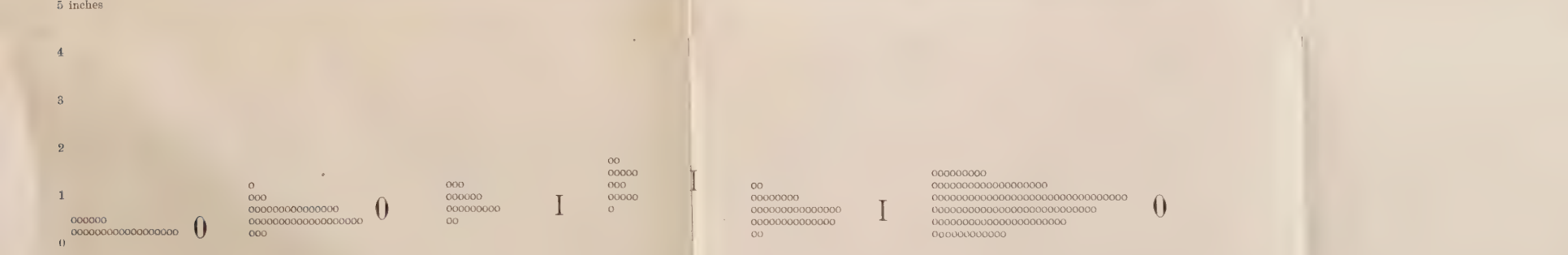


Table III. 1905–06.

Measurements of Oysters from Volstrup. In centimeters.

• indicates oysters with spat. 0 and I indicate year groups.

No. 1.
Pole dredge.
26. April 1906.

15 cm.
14
13
12
11 oo
10 ooooooo
9 ooooooooooooooooooo
8 oooooooooooooooooooooooooooooooooooooooo
7 ooooooooooooooooooooooooo
6 oooooooooooooooooooo
5 ooooo
4 oooooooo
3 ooooooo
2 ooo
1 ca. 100 quite small spec. under 1 cm.
0

No. 2.
Pole dredge.
18. June 1906.

ooooooooo
••ooooooooooooooooooooooooooooooooooooo
•••••••oooooooooooooooooooooooooooooooooooooooooooooooooooooooooo
•••••••ooooooooooooooooooooooooooooooooooooooooooooooooooooooooo
ooooooooooooooooooooooooooooooooooo
oooooooooooo
ooooo
ooo
ooooooooooo
ooooooooooooooooo
47 spec. under 1 cm.

No. 3.
Pole-dredge.
4. August 1906

oo
ooooooooo
9 spec. under 1 cm.

No. 4.
Pole-dredge.
3. August 1905.

ooooooooo
ooooooooooo
oooooooooooo
oooo
oo
o
ooo
numbers quite small 2—3 mm. 0

No. 5.
Pole-dredge
17. August 1906

oooooooooooooooooo
Of these only a few at 1 cm. or 1_{0}–1_{5} cm., most low

Further under 1 cm
10 Millimeters
9 ooooooo
8 o
7 ooooooo
6 ooooo
5 oooo
4 ooo
3 oo
2 o
1 A number at ca. 1 Millimeter.

No. 6.
Dredge.
26. April 1906.

cm.
13 oo
12 oo
11 ooooooooooo
10 oooooooooooooo
9 ooooooooooooooooooooo
8 ooooooooooooooooo
7 ooooooooooo
6 oooo
5 ooo
4 oo
3 oo
2 oo
1 13 spec. under 1 cm.
0

No. 7.
Dredge
18. June 1906.

oo
ooooooooooo
•ooooooooooooooooooooooooooooooooooo
•••••ooooooooooooooooooooooooooooooooooooooooooooooooooo
•ooooooooooooooooooooooooooooooooooooooooooooooooooooo
ooooooooooooooooo
ooooo
ooooooo
ooooo
ooooo
ooooooooo
5 spec. under 1 cm.

No. 8.
Dredge.
3. August 1905

oo
ooooo
ooooo
ooooooo
oooo
ooooooo
o
o
oo

No. 9.
Dredge.
8. August 1906

Further under 1 cm
10 Millimeters
9
8 o
7 oo
6
5
4
3
2
1

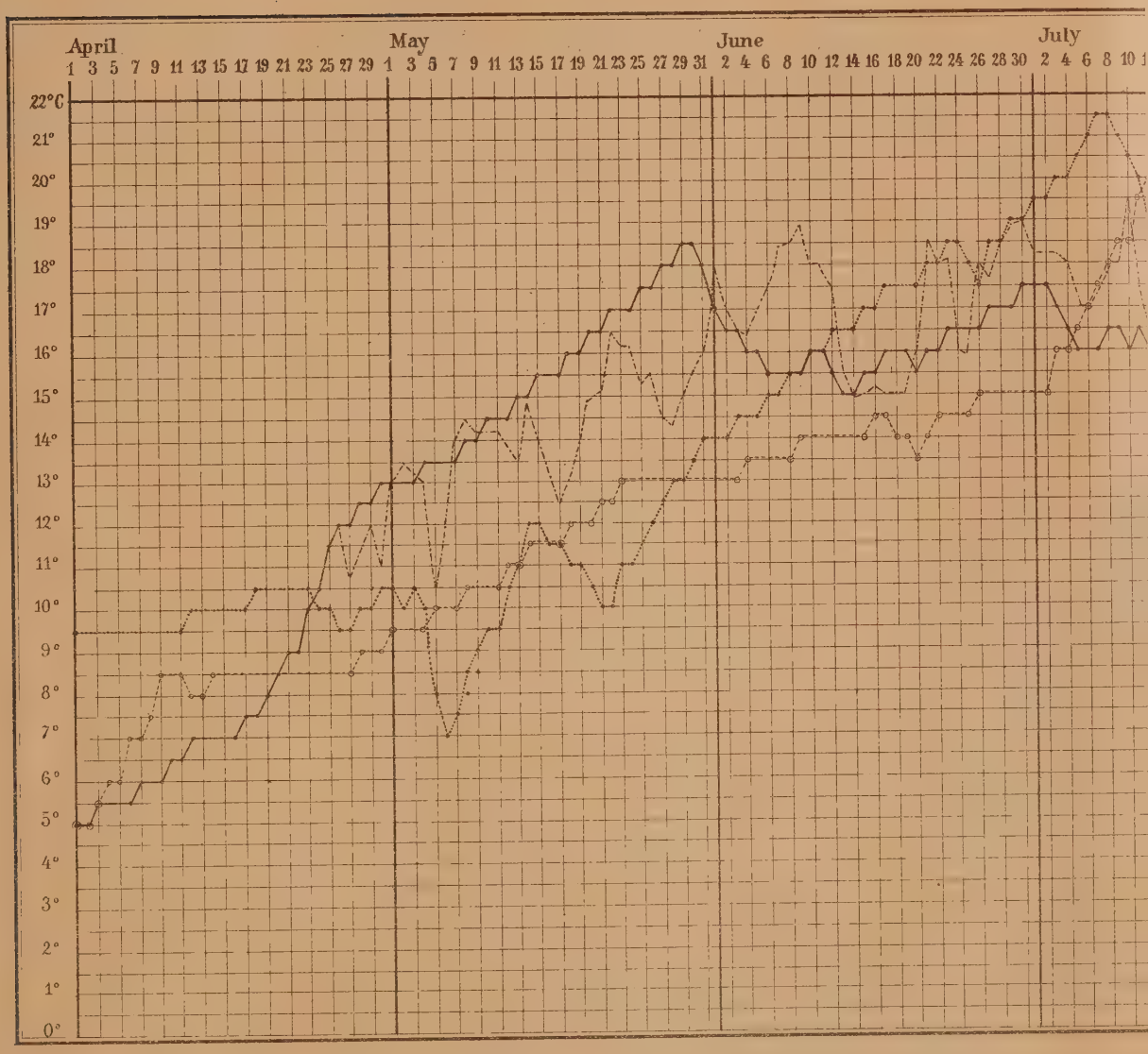
No. 10.
Dredge
20. August 1906.

o
oo
ooooooooooo
ooooooooooo
ooooooooooo
oooooo
o
oooo
o
oooooo
ooooo
Further under 1 cm
10 Millimeters
9
8
7
6 o
5
4
3 oo
2 ooooooo
1 ooooo
ca. 20 spec. under 1 Millimeter. 0

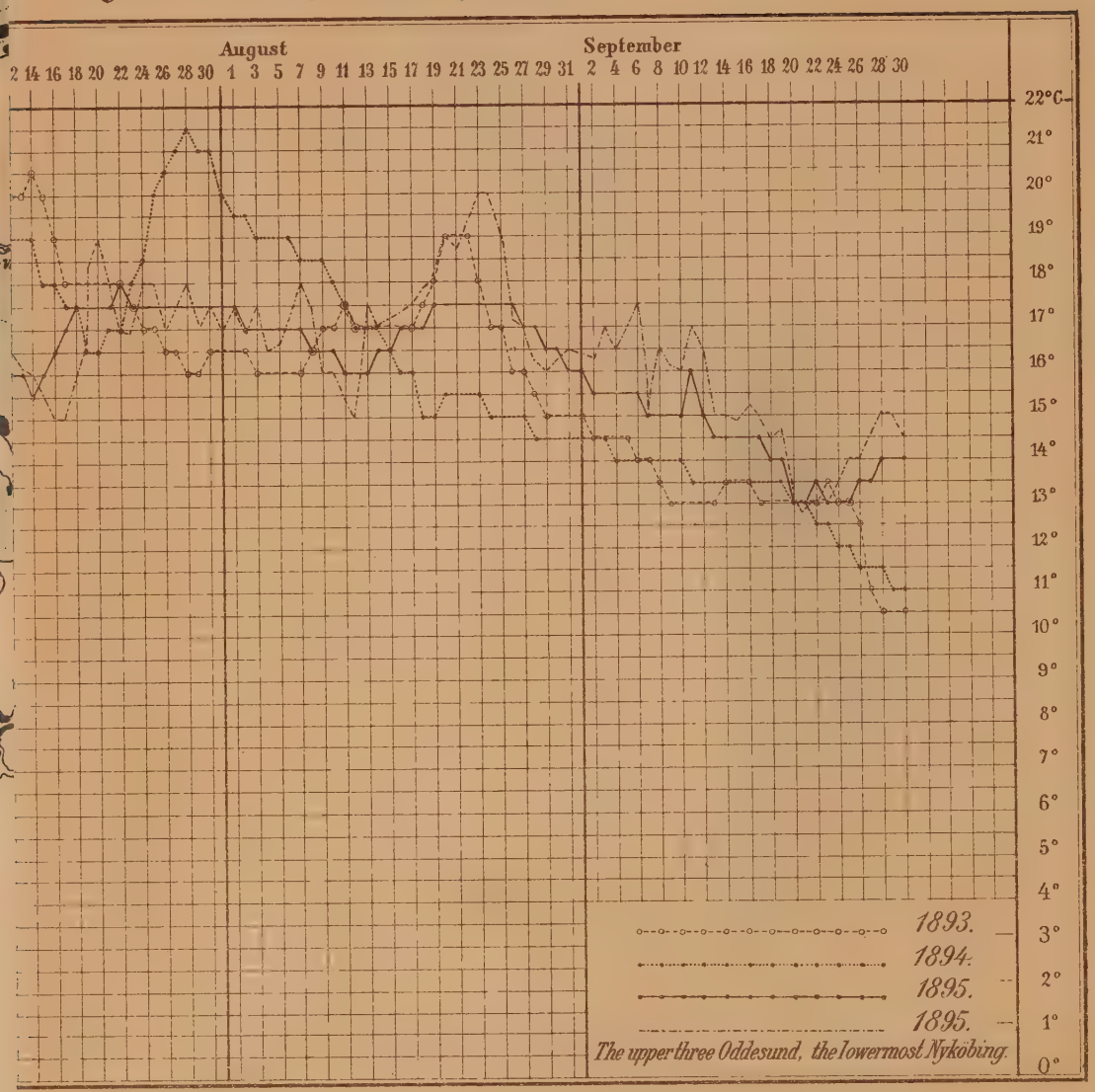
Oyster Banks in the Lim Fjord according to the l
(East of Lögstör according to the older Chart of Colli
The numbers indicate salinity in % during the period
Sept. 4th.-11th. 1890
3 fathoms line.
1907
SCALE IN MILES.
0 1 2 3 4 8
VESTER -
HAVET.
Thisted
Thisted Bredning
2,66
Dragstrup Vig
2,56
Nykjöbing
MORS
Agger
Krik
2,39
Visby
Bredning
Thyborön Kanal
Thyborön
Helligsö
2,58
Skibsted Fjord
2,87
3,04
Kaas Bredning
JEGINDÖ
Nissum Bredning
THYHOLM
3,04
Kaas Hoved
Spättrup
Horbeere
3,18
3,19
Oddé Sund
Lemvig
VENØ
3,05
Nygaard
Venö
Bugt
3,04
Struer
Volstrup Gd
Handbjerg

atest information.
ns.)

Surface temperatures.



Oddesund 1893-95.
Nyköbing (M) 1895.



Second Report

on the

Oysters and Oyster Fisheries in the Lim Fjord

with 6 Tables and 1 Appendix

by

C. G. Joh. Petersen.

Technical Adviser to the Department of Agriculture in matters concerning the oyster fisheries.

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In my »First Report on the oysters and oyster fisheries in the Lim Fjord«, Report XV for the year 1907, it was explained that many oysters in the Lim Fjord could not reach the standard size 8 × 3 cm. fixed by the Government; that this should therefore be reduced and that the fishery should be carried on more energetically on the whole than was at present the case, as far too many oysters died of old age without being of use to anybody. To be able to give definite figures for the further elucidation of these questions, I undertook a series of investigations in 1907 on the stock of oysters in the Lim Fjord at a number of different places. These investigations might easily have been carried out on a larger scale and with larger quantities of oysters, but I believe that what has been done is sufficient, on the one hand to throw light on many points where such was very necessary and on the other to provide a comprehensive view over many points where such was advisable.

The investigations have been specially directed to determine, how large the oysters were which were taken by means of the pole-dredge, the dredge and diving respectively on the different banks, thus in other words, how large the oysters were which were growing at the different places; secondly, how the present standard 8 × 3 cm. and the standard proposed by myself, which is 1 cm. smaller (7 × 3 cm.), suited these oysters. Further, it appeared during these investigations that diving enabled a good estimate to be made as to how many millions of oysters were living in the fjord at the moment. Such diving investigations were therefore carried out. Lastly, various other investigations of biological interest were undertaken, amongst these marking of oysters.

Table I shows the length of oysters obtained by the pole-dredge at various places in the Lim Fjord. The oysters were measured lengthways, that is, from the point of the shell at the hinge to the opposite edge. When the oysters are measured by the inspectors with the 8 × 3 cm. iron standard, they pass through this sometimes lengthways, sometimes broadways. Such a method of measuring could not be used for these investigations, as according to it an oyster 8 cm. in length would sometimes be a standard oyster if it were thick and broad, whilst on the other hand an oyster of 10 cm. might be undersized if it were thin and narrow. We shall see later regarding the relation of this standard to the length of oysters.

The Table shows in the last column, which gives the number of all the oysters of the same length from 1—12 cm. taken in the pole-dredge, that 8 cm.

as a rule is the most frequent size, next 7 cm. and then 9 cm. At many places in the fjord the oysters are smaller than at others, as 7 cm. is sometimes more frequent than 8 cm. (see Table I); but the time of year has no influence on the size at 7—8—9 cm. The localities on Table I are arranged chronologically from 8/IV—8/X 07. By far the great majority of the oysters taken by the pole-dredge measured 7—9 cm.; of the larger from 10 to 12 cm. only a few hundred specimens were found, and of the lower from 6 to 0 cm. a good many were indeed taken but not nearly so many as of the three sizes 7—9 cm. together. The maximum for the oysters taken by the pole-dredge is thus at 8 cm. as a rule, but it would be easy to show a number of banks and large parts of others, especially in very shallow water, 2—4 feet, where the oysters taken by pole-dredge had their maximum at 7 cm. It should be remembered that the last column in Table I only gives an approximate picture of the sizes taken by the pole-dredge, as the figures of the column have been arrived at by summing the oysters together from localities where they have a somewhat different relative size; the totals show however that the average size for oysters taken by the pole-dredge falls at 8 cm., 7 cm. coming nearest afterwards and then 9 cm.

A smaller maximum can be noticed amongst the lower sizes, 6—0 cm., at certain localities, for example, at Langer Hage 12. April, Trehuse 8. April and Feggeklit in April. This maximum which represents 1 to 2 younger annual groups is not always situated at quite the same cm. in the Table; it is most distinct in the spring at 2—3 cm., but often becomes less distinct in the course of the summer when the small oysters grow up and gradually join on to the large group; see for example the Feggeklit measurements. It is not always easy however to follow the growth from the Tables; but in nature we can often see the new, thin outer margin on the shell which the small oysters have added in the course of the summer. It is naturally through the growth of these younger annual groups that the large group at 7—9 cm. is maintained throughout the year. It represents also the adult oysters, which grow but little but begin to spawn at 6—7 cm. and die at 8 cm. There seems therefore here, as in so many other animals, a certain amount of simultaneousness between the stoppage in growth and appearance of reproduction.

It might well be imagined that the presence of so many of these small oysters, which we took with the pole-dredge, and also certainly at many other places not investigated, was due to too severe a fishery; we know for example that the stock of plaice can be over-fished so that only the young, small individuals remain: but there can be absolutely no talk of this as regards the oysters in the Lim Fjord; the pole-dredge has not been used on several of these banks by the lessees during the last 7 years, and but little of this kind of fishing on the whole has been done in the last 4 years, so that overfishing cannot be thought of (see below Appendix A: Statistics of the standard oysters fished by the lessees from the season $19\frac{0}{0}\frac{0}{0}$ to $19\frac{0}{0}\frac{6}{7}$). During the last four years only 88,000 oysters in all have been taken by pole-dredging, and these in Sallingsund, Livø Bredning and at Fur; in $19\frac{0}{0}\frac{3}{4}$ and $19\frac{0}{0}\frac{6}{7}$ no pole-dredging was done. The lessees were able to obtain sufficient oysters from the regular boats for dredging and diving.

The illegal fishery carried on in the Lim Fjord might also be thought of

and especially naturally with regard to the oysters taken by pole-dredge, which often lie in so shallow water that they can be taken by hand. Several cases of such a fishery have come to my knowledge at second or third hand, but I am certain that it is only carried on to a relatively small extent and there can be no talk of trading with such oysters on a large scale. We have, in short, nothing to do with overfishing here; these oysters taken by pole-dredging could never become larger than as shown in the Tables at many of these places in shallow water of 2—6 feet: they are already full-grown and ought to be fished.

In calling oysters of 7 (8) cm. and upwards full-grown oysters, this should be understood as meaning that many oysters never become larger than 7 to 8 cm. but die of old-age; others become, as the Table shows, 10, 11 and some few 12 cm.; these must be regarded as mainly exceptions, just as we find some men taller than others. As there are fewer oysters at 9 cm. than at 8 cm., we may conclude that many die of old age already at 8 cm. in length. The reason why the oysters in shallow water do not become so large as those in deeper water, I am unable to completely explain; it must be taken as a fact that such is the case as a rule.

How large the areas are where these pole-dredge oysters occur, it is impossible to say from lack of sufficient information regarding the shallow water banks; but I have seen these oysters along many miles of the coast. When the algal growth is feeble in the spring, it is easy to see the oysters by sailing over the banks in a small boat; in clear weather they can then be observed on the bottom if the water is clear. During these investigations two men have often fished many hundreds of these small oysters in an hour with two pole-dredges, i.e. small nets or dredges at the end of long poles by means of which the oysters lying on the bottom can be reached and taken up. It is not only however with regard to the length that the pole-dredge oysters are smaller than the deep-water oysters (from 2—5 fathoms in the Lim Fjord), they are also thinner. Further, they have smoother shells, gnawed by various gastropods, and with their hard and clean shells resemble the small Dutch oysters so much esteemed by many, with which at any rate in good years they might well be compared in every regard; also in regard to size.

Table II shows the length of dredged oysters from a number of places in the Lim Fjord. Here as with the previous the oysters are measured lengthways. All the dredged oysters were taken by the »Sallingsund« in water between $1^1/_2$ and 5 fathoms, thus in deeper water than those taken by pole-dredge. The latter as mentioned were all taken by the small boat of the »Sallingsund« in 2—6 feet water. Whilst the oysters taken by pole dredge have their maximum as a rule at 8 cm., the dredged oysters have theirs at 9 cm., thus considerably larger. The size is not the same everywhere, but varies somewhat between 8 and 9 cm. at different places. Here we also find an adult group which remains unchanged at the same size at all times of the year, but from 9 cm. upward against 8 cm. and upward for the oysters taken by pole-dredge. Amongst the smaller oysters a maximum at 3—4 cm. can be seen in spring; in autumn it has a tendency to rise and join on to the full-grown group; see for example Trehuse, Feggeklit east and Revelkær Hage.

It might be thought perhaps as regards the dredged oysters that the adult group was artificial, partly caused by overfishing; but it also appears here in nature that the growth is easy to observe in the young oysters under 7—8 cm. and seldom well marked in the larger; further, reproduction begins at 6—7 cm. in length; and lastly, from the calculation below of the small product of the fishery and the rich stock in the fjord, we know that so little fishery has been carried on during the last 23 years, either not at all or only about 1 million yearly that it could have absolutely no influence on the appearance of the adult group; at any rate not on the stock of the fjord as a whole. It might be thought that the fishery had some influence on the well fished banks; but even here no decrease in size could be observed; for the time being only the number of oysters has been influenced and that only to a very small extent. The fishery both by diving and dredging is so carried on that a bank is never fished clean, only approximately; fishing is carried on over the whole of the fjord wherever most oysters are supposed to be and where the wind and weather and the convenience of the fishermen are most suited and suitable. On the other hand Table II shows that the oysters in Nissum Bredning are larger than in the other regions; and it has always been so, so far as is known; here 9 and 10 cm. are equally frequent, elsewhere it is 8 and 9 cm.

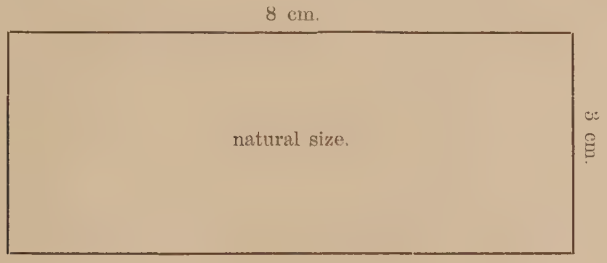
The oysters in Table II were dredged in the period from the 9th to 20th April by means of a ca. 1 fathom broad dredge, like those used by the oyster fishers on the banks in the North Sea; this dredge was sometimes provided with teeth sometimes not. After April 23rd however two smaller dredges fastened alongside one another, the one with teeth the other without, were used; their spread was thus almost over a fathom from side to side and seemed to take just as many oysters. The oysters dredged at Trehuse on April 23nd were taken partly with the large, partly with the small dredges.

It would be desirable to know more regarding the age of oysters at any definite length, but the statistical method by measurements as the Tables show gives but incomplete information, clearly because the growth of oysters is different under different conditions and perhaps also in different years according as these are warm or cold. Thus I have long regarded the oysters under 7 cm. in the Tables as containing 2 annual groups coalesced with the usual maximum at 2—4 cm., and I have been further strengthened in this view during this year. In May 1907 I was able to examine a tarred raft in the possession of a fish dealer which had lain in Nykøbing harbour since Whitsuntide 1905, thus from the middle of June 1905, and was now in the spring of 1907 taken up to be dried, cleaned and tarred. Two annual groups were fixed on the raft in May 1907, each numerous, one from 1906 of ca. 2 cm. in length and one from 1905 of 4—6 cm. If this was the general growth in the fjord, all oysters of 7 cm. and above should be 3 years old and more; but I do not think that the oysters on the banks would grow so quickly as those on the raft or on other similar artificial objects; of this I have already had previous evidence. But in the estimate that the oysters of 4—5 years old on the banks are 7—8 cm. and more I do not think we are much in error. To investigate the point more closely we must find a suitable method of marking oysters. I have been recommended from Holland this year to try

painting the shells with red lead or tar; but these are not sufficiently durable for our purpose; it is only recently that I believe I have found a better method. It will certainly prove by this method that the oysters on the different banks grow as a rule fairly quickly, until they reach 7—8 cm. in shallow water and 8—9 cm. in deeper, but much more slowly after that or not at all.

The present standard for oysters consists of a quadrilateral iron frame, with an opening of 8 cm. on the one side and 3 cm. on the other.

All oysters which are able to pass through this frame, whether lengthways or broadways, by turning or twisting, must be returned to the water if taken up by the fishermen, in order to be allowed to grow larger before being fished up again. I have closely investigated how this standard works in practice by using it on a number of the oysters fished during these investigations, especially on those taken by the pole-dredge and by diving.



As the oysters under 7 cm. must be considered as a rule unfit for the market or food, at least as regards the race which occurs in the Lim Fjord at present, I have only used the standard on oysters of 7 cm. and upwards. Of these (see p. 15 Table Ia) 1612 oysters taken by the pole-dredge on May 25th and July 19th at Feggeklit, on July 3rd in Faarup Vig, on August 29th in Venø Bugt and on 15th—17th August at Trehuse have been examined. Of these 1612 oysters only 178 were standard size, as all at 7 cm, went through the frame of 8×3 cm., almost all at 8 cm. and $^3/_4$ths of those at 9 cm., even 15 at 10 cm. passed through; only the 12 which were 11 cm. in length were all standard size (see Table Ia, last two columns). All fishing with the pole-dredge is therefore practically impossible at many places in shallow water according to this standard; and even if pole-dredging would pay, yet most of the oysters, namely almost all at 8 cm. and $^3/_4$ths of those at 9 cm., would die of old age without being fished; since the oysters at 8 cm. and above must as a rule be considered as full-grown at these places (Table I, p. 14).

Even if pole-dredging did pay the fishermen, especially in earlier years, with the same standard, this was due on the one hand to the fact that the oysters on a few of the banks as already mentioned were of much greater size, and on the other that in good weather pole-dredging can be carried on in deeper water than we fished. What I wish to emphasize on this occasion is the fact, that there are large areas on which the oysters when full-grown are so small that they cannot

be fished according to the present standard. For the oysters taken by dredge and by diving, which are almost always fished in deeper water, $1^1/_2$—5 fathoms, the conditions are less unfavourable, as the oysters there are all both longer and thicker.

Table III shows the length of all the oysters obtained by diving at 15 places during my investigations. The localities are situated between Løgstør and Thyborøn. The method of fishing was to anchor the usual boats for oyster diving on the bank by means of two anchors, so that they remained quite steady. The diver had a definite length of line each time, so that the depth being known we could approximately calculate how far he could travel round about the bank, and therefore how large an area had been fished. All the oysters on this area were as far as possible taken up and measured; but it is impossible to fish the bank quite clean on account of various practical difficulties; sometimes the diver would estimate that ca. 50 oysters remained, for example, where there were large stones on which they were too firmly fixed. On muddy ground some might easily be covered by mud, and the water here is easily disturbed so that all the oysters could not be seen. It appears from Table III, that the full-grown group is most strongly represented at 8 cm., just as for the oysters taken by pole-dredge, then at 9 cm. and not at 7 cm. as for the latter. A maximum for the young oysters occurs at 3 cm.

Of all the 3404 oysters over 7 cm. obtained by diving, 3318 were tested by the standard 8×3 cm. (see Table III); only 1845 did not pass through this; some right up to 10 cm. could pass through like the oysters taken by pole-dredge; at 8 cm. only 27 % were retained, at 9 cm. 70 %. The details of these measurements appear in Table IIIa. I have given the Tables with the details appended, because they give a good view over the relative numbers of the oysters at different sizes living at this moment in the Lim Fjord. If the size of the oysters in the Lim Fjord should change, we have here a material by means of which we can detect the change. It is just such a material we lack for the plaice fishery in the Kattegat for the years about 1880.

That the Tables over the diving investigations have also an other and special worth will be shown later.

Table II over the dredged oysters shows that they in general have their maximum at 9 cm., 8 cm. is the next almost as frequent and then 10 cm. They are thus distinctly larger than the oysters obtained by diving shown in Table III. This difference may arise from the fact that the diver took up all the oysters, both large and small; under ordinary conditions he only takes the large; but it is well-known that diving brings up more undersized oysters than any other mode of fishing. There is room here for individual choice. By means of the method used in the diving operations in the present instance we obtain the best picture of the kind of oysters which actually occur on the banks, since all are taken up as far as possible. We endeavoured to do something similar in our experiments with the pole-dredge; but it is remarkable that the dredge has a tendency to leave behind a certain intermediate size of oysters; this feature will certainly prove to be different under different conditions and with dredges of different construction.

The important thing is that both our pole-dredging and diving experiments may be considered as giving the best possible information regarding the stock of

oysters actually at the places investigated. The standards 8×3 and 7×3 have therefore been specially experimented with on the oysters obtained by these methods of fishing.

We might now say, to make the matter more easily understood, that the pole-dredged oysters are full-grown at (7) 8 cm., those obtained by diving at 8 (9) cm., the dredged oysters at 8 (9) cm. All oysters which are at least ca. 8 cm. and above should really be fished for; but the present standard allows only ca. $^1/_4$th of those at 8 cm. and only 70 % of those at 9 cm. to be taken.

No investigations from earlier times are known to me which would in any way indicate that just this standard of 8×3 cm. is the correct one. Professor Eschricht and the Government always held to a smaller standard in earlier years.

The statistics for the years 1870—1877 give us distinct evidence that many of the large oysters occured at that time in the fjord, as ca. 45 millions of them were fished during the 7 years; but then they seem to have decreased in number, not that they were all fished out, but the regulation that a boat must be able to take at least 1000 of them in one day made further fishery for them impossible. I do not believe in the rumours that a storm and flood with ice to aid them destroyed this stock; all evidence of this is quite wanting. It has been said that many dead but still connected shells were found on the banks, but such are found every year. Whether they have just died or have lain on the bottom for several years cannot be determined, as the soft parts of the oyster soon disappear when the oyster dies so that no trace of them can be found a few days after. This point has been investigated by placing dead oysters on the banks at Feggeklit. Within three days all the shells had been cleaned by the flesh-eating animals: gastropods, crabs and worms; even within 10 hours all the soft parts had been completevely removed. I judge of the conditions in the seventies in this way, that a drecrease in the stock of the large old oysters could really be noticed; I belive that a yearly fishery of ca. 6 million is quite respectable, especially if regard is taken for the restrictive regulation of 1000 oysters per boat per day. This regulation was probably introduced in part because it did not pay to fish when so many could not be taken as a rule. We have here therefore some evidence of what the Lim Fjord can yield in this way: 6 million of old oysters each year for 7 years. All foreign countries and also in part our own have now become accustomed to eat smaller oysters; the Dutch and English small oysters flood the present markets over the whole of North Europe; and the duty in foreign countries favours to a great extent the small oysters, being per kg. and not per oyster; lastly, what is of most importance to Denmark, we would clearly produce several millions of oysters with a smaller standard size than the present. If we only enrolled soldiers of 72 inches and above, we should have many fewer than if we took them down to 64 inches; similarly with oysters; if as at present we only take those about 9 cm. we have relatively few; a reduction of 1 cm. in the standard would give many more. A reduction from 9 to 8 cm. would be for oysters just the same as a reduction from 72 to 64 inches for the soldiers, as $\frac{7}{6}\frac{2}{4} = \frac{8}{8}$. The oysters are so short that 1 cm. is of very great importance.

In order to test how a smaller standard of 7×3 cm. would work com-

pared with the present 8 × 3 cm., I got some of the former size forged and Table Ia shows the result for the oysters taken by pole-dredge, and Table III and IIIa for those obtained by diving. Of the 1612 pole-dredge oysters investigated by both standards the large gave only 178 standards the small on the other hand 749 or quite 4 times as many. It kept almost all the oysters of 9 cm. in length, somewhat over the half of the 8 cm. and but few of those at 7 cm.; the last because they were fairly thick and could not therefore go through the standard. Just for this reason the standard was made like a frame, as these small, thick oysters are old and grow no further.

From the purely practical aspect this standard gave very fine saleable oysters, the smallest of which apart from consideration of the price I would rather eat than the large; their shells are clean and solid, not double nor containing evil-smelling water, as is often the case with the large oysters.

Table III shows that of 3318 oysters obtained by diving which were measured, 1485 were standards according to the large standard, but 2520 according to the smaller; thus well towards the double. As the oysters taken by dredge and diving are always longer and thicker than the pole-dredge oysters, the disproportion under the large present standard is not so great in their case as for the oysters taken by pole-dredge; but with the small standard nevertheless, a boat would quickly fish almost twice as many oysters as it does now. As these smaller oysters are considerably younger than the large, the stock would be renewed all the more quickly, and the introduction of such a standard would prevent so many oysters dying of old age, such as is now the case. How large the production of the fjord would increase through this apparently small reduction of the standard size, it is impossible to say; but with the same number of fishermen and the same amount of work, the catch would at once be doubled.

If in 1886 the standard for oysters had been reduced this one cm. instead of total closure for 4 years being enforced, things would certainly have been much better. I shall endeavour here to show that the stock in the fjord without its productivity being lessened may be considered as capable of supporting such a more severe fishing.

Sample dredgings can only give a momentary picture of whether many or few oysters can be fished on a bank; this may be covered by dead zostera so that the dredge takes hardly any oysters even though many may be there. On sandy bottom also the oysters are said to be able to lie buried in holes formed by themselves, over which the dredge passes without taking the oysters. If poor results are thus obtained from dredging, great care must be taken in drawing conclusions as to the richness or poverty of the oysters banks. Even if the dredge is working as well as it can, yet it springs over a number of oysters, so that sample dredgings can never show how many oysters there actually are on a definite limited area. It is quite different with pole-dredging and diving. In fishing with the pole-dredge stakes can be driven into the ground and all the oysters between these fished up. As the area between the stakes can be easily measured it is possible to calculate how many oysters there are per square foot of ground. I have made some trials in this direction during the year and found for the west side of Feggeklit that there was approximately one oyster to each 40 square feet; ca. 11,200

square feet were investigated and only the oysters over 7 cm. included. On the east side of Feggeklit 1000 square feet were examined and 291 oysters over 7 cm. were found; thus a little over 1 oyster per 4 square feet. The numbers on the actual pole-dredging banks will probably lie between these two densities; but as we have absolutely no chart over the extent of these banks in the fjord, because practically no fishery is carried on where the smaller oysters live, we can for the time being form no estimate of how many million oysters of this kind there are in the fjord; this must be learnt in the future; but I am certain that it is a matter of long, narrow stretches of altogether several miles.

It is quite different for the dredged banks on which diving is also done. From early times they have been numbered and mapped out by the lessees and inspectors in company. Such a chart has been published in my earlier Roport (XV). Although this chart cannot make great claims to being very accurate, as regards the size of the areas, yet it is possible by means of it to obtain a fairly correct picture of the extent or surface area over which the oyster banks in the Lim Fjord extend in all. This has been calculated to be $2,_{91}$ Danish square miles [1]) or 1676 million □ feet. All the banks marked on the chart are included here with exception of those east of Løgstør. Further the large new bank, which embraces the three fairly large banks on the chart N.E. of Feggeklit, is included according to the boundaries at present known.

In order to obtain some notion of how dense the oysters are on the banks, 15 diving experiments were made, distributed over all the districts, as already described on p. 7. We were not content only with the area calculated from the length of line given out to the diver and the depth of water; the diver himself by means of a leadline measured the diameter of the circle fished over by him on the bottom; both metods agreed very well. The details of these experiments can be seen from Table IIIa. The number and length of all oysters over 7 cm. are represented; Table III shows likewise the number and length of the smaller oysters obtained by diving and it is also stated how many standard oysters there were according to the two standards 7×3 and 8×3 cm.; further, the area fished over is given in square feet and lastly the number of oysters over 7 cm. found per square foot or the density is stated. The latter varies from $0,_{75}$ to $0,_{11}$, i.e. from $0,_{75}$ per 100 □ feet to 11 per 100 □ feet. We thus see at once that the oysters are nowhere lying in layers on the top of one another. The expression »banks« should be understood as meaning banks on sand and stones on the fjord bottom analogous to fishing banks; the oysters themselves cannot form banks, at least not the living oysters. Dead shells might however be deposited on the top of one another generation after generation and at last form a thick layer.

There are many oysters nevertheless on the banks. The total area of these according to Table IV is 1676 million □ feet.

To come to as exact a result as possible, the density found in each district by diving was made the basis of the calculation as to how many oysters were found there. We see that the density is very low in Nissum Bredning, $0,_{75}$ oysters per 100 □ feet, but large at Trehuse, Hannæs, Visby Bredning and Kaas Bred-

[1]) 1 Danish square sea-mile $\doteq 7407^2$ □ meters = ca. 16 Eng. square nautical miles.

ning, namely about 11 oysters per 100 □ feet; but we also notice that these densities do not vary so extremely as to prevent us from obtaining some estimate of the size of the stock by their means.

The areas given on Table IV have been found by Engineer-Captain, Cand. polyt. J. Bast, who has also helped me with the preparation of the Tables, in the following manner:

By means of tracings on the original marine chart, on which the oyster banks were marked off and which — greatly reduced — is reproduced in the Chart accompanying my above-mentioned Report of April 1907, the separate small areas within each main district (Sund, Bredning or Vig) are brought together side by side to one, as far as possible, »compact« area; by means of the planimeter this is then measured in □ miles of 1852^2 □ meters = ca. 5900^2 □ feet = ca. 34,810,000 □ feet, and the result is then stated in millions of □ feet for each of the 9 main localities dealt with.

On summing together the numbers of all the oysters over 7 cm. in the different districts we find that ca. 90 millions of oysters live in the whole fjord; of standard oysters according to the present standard ca. 40 millions; according to the smaller 7×3 on the other hand ca. 70 millions.

As mentioned, no attention is paid in this calculation to all the smaller oysters which can be taken by pole-dredge, as the extent of the banks is not known, nor to all the scattered oysters which are found for example over almost the whole of Livø and Løgstør Brednings, and which are often taken in numbers in the flounder set-nets and seines.

Owing to the small number of oysters taken by diving in Nissum and Thisted Brednings the calculations for these are less trustworthy; the density is perhaps too low in both cases; I thought it superfluous however to make more of these experiments; for the time being there are certainly sufficient oysters to begin with.

However approximate the whole calculation may be, owing to difficulties in determining the exact extent of the banks and the density everywhere on them, I believe that all will agree with me that there are several scores of millions of oysters in the Lim Fjord at this moment, both according to the present and especially the smaller standard; and therefore that far too little fishing is carried on when as now only ca. 1 million oysters are fished in the year. As the oysters grow up within 4—5 years, the return or output must be based upon a much shorter number of years than as now upon scores of years.

To state how many millions might be fished yearly without reducing the productivity of the stock is impossible, as we do not know the scale on which the stock is annually on an average renewed; but if 5 millions were taken yearly according to the smaller standard, there would certainly be at present no danger of overfishing; and for the time being the market can scarcely take more.

If we ever should come to the time when we can use more oysters than the Lim Fjord can yield without help, it will then not be impossible probably to improve matters by means of the experience learnt in other countries. As Eschricht proposed in earlier days, it would be possible to introduce other races of oysters, not to improve the race in the Lim Fjord, but to allow them to grow up to

market size Experiments in this regard as well as in various ways might be commenced already, so that we may be fully prepared to carry the matter further if necessary, as we might even be obliged once again to completely close the banks as in the years 1887—1890. The stock on the natural banks especially should not be over-taxed without full preparation and knowingly. It must be the care of the person who is entrusted in future with the superintendence of the Lim Fjord banks to follow the course of things from year to year, so that he may be prepared in good time to meet all difficulties arising from a future severe fishery. Changes in the natural conditions might of course place insurmountable difficulties in the way; the closing of the Thyborøn Channel alone would destroy all oyster life in the fjord. Such an expert should be well aware of the responsibility, which may arise from fishing too little and from fishing too much of the stock.

Accurate knowledge of the fjord and of the oyster fisheries as a whole, as also of the experience won in foreign countries should be required of him and his responsibility may be great enough even with this knowledge. Only by making continued biological investigations will he be able to justify his acceptance of the post. The early history has shown very clearly what the lack of sufficient investigations leads to, both for the State and the public.

Table I. **Length of all the Oysters fished with the pole-dredge by the Biological Station from April to October 1907.**

	Trehuse 8/4.	Feggeklit (*crest side*) 9/4.	Hanklit 10/4.	Langer Hage 12/4.	Volstrup 19/4.	Feggeklit (*east side*) 20/4.	Draaby Vig 20/4. (Alsted Church)	between Grønner Odde and Nederby. *Fur* S. 27/4.	Feggeklit east 30/4.	Nakken to Ertbølle Hoved 10/5.	Oddesund N. 14/5.	Volstrup 15/5.	Feggeklit east 22/5.	Feggeklit west 25/5.	Feggeklit east 26/5.	Feggeklit east 25/5.	Faarup Vig 3/7.	Feggeklit east 19/7.	Trehuse 15/8 & 17/8.	Breinholt Klint 29/8.	Feggeklit east 24/9.	Trehuse 26/9.	Langer Hage 30/9.	Faarup Vig 30/9.	Trehuse 8/10.	Feggeklit east 8/10.	Total
Depth in feet	3—5	3—4		6	1—6	3—4	4—6	3—5	4—5		2—5	3—6	3—6		6	3	2—3		6	3—6	3—4	4—6	4—6	3—5	2—4	2—4	3—5	
Length	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.
12 cm.	2	0	....	1	1	0	1	0	0	0	0	....	....	....	....	....	....	....	.....	....	1	1	....	2	....	....	9
11 —	15	0	....	8	7	11	1	0	10	2	3	....	29	....	4	4	1	3	3	1	6	3	3	9	3	2	128
10 —	34	3	1	32	27	39	6	7	32	15	9	4	113	3	25	29	11	22	16	1	31	29	35	21	19	27	591
9 —	89	20	2	67	96	126	38	48	107	64	**22**	36	286	30	85	59	75	75	68	22	69	56	58	53	60	44	1755
8 —	**90**	75	5	**74**	156	**153**	57	**108**	**116**	**92**	16	**107**	**414**	95	**117**	**108**	**150**	**100**	**115**	68	**53**	**65**	**67**	**68**	**81**	**61**	**2611**
7 —	46	**121**	5	31	**178**	99	**75**	**108**	84	44	13	80	208	**108**	60	75	127	63	75	**89**	32	41	25	37	45	44	1913
6 —	18	63	....	13	115	34	23	37	37	15	7	28	58	45	18	40	36	20	22	46	7	18	25	7	37	21	790
5 —	10	12	....	8	40	5	5	13	4	5	1	....	12	14	8	16	23	8	29	21	5	15	10	9	25	21	319
4 —	19	6	....	12	29	9	6	2	5	1	0	....	(ca. 40*)	2	5	5	38	10	17	16	5	5	9	10	19	11	251
3 —	36	1	....	24	19	9	25	1	21	3	2	....		1	....	8	31	14	15	8	7	6	4	8	13	9	275
2 —	36	3	....	21	26	31	38	0	16	1	0	....		3	....	10	10	8	5	18	5	2	1	9	13	11	277
1 —	36	0	....	3	12	8	30	0	4	0	0	....		3	2	1	8	....	3	7	2	....	....	1	4	6	140

* distributed equally over the four sizes in the totals.

Oysters of 7 cm. and above, **taken by pole-dredging** in 1907, tested by the standards 8 × 3 cm. and 7 × 3 cm.

Table I a.

Date	25/5			25/5			3/7			19/7			15/8			17/8			29/8			No. of oysters tested by the »small« and »large« standards.	Standard oysters			
	Feggeklit west Løgstør Bredning			Feggeklit east Løgstør Bredning			Faarup Vig Sallingsund			Feggeklit east Løgstør Bredning			Trehuse Sallingsund			Trehuse Sallingsund			Venø Sund Venø Bugt				with 7 × 3 cm. Standard		with 8 × 3 cm. Standard	
Depth in feet				6			2—5						6			3—6			3—4							
Length cm.	Total Num.	Num. 7×3 cm.s	Num. 8×3 cm.s	Total Num.	Num. 7×3 cm.s	Num. 8×3 cm.s	Total Num.	Num. 7×3 cm.s	Num. 8×3 cm.s	Total Num.	Num. 7×3 cm.s	Num. 8×3 cm.s	Total Num.	Num. 7×3 cm.s	Num. 8×3 cm.s	Total Num.	Num. 7×3 cm.s	Num. 8×3 cm.s	Total Num.	Num. 7×2 cm.s	Num. 8×3 cm.s		Num.	%	Num.	%
11	...	....	....	4	4	4	1	1	1	3	3	3	2	2	2	1	1	1	1	1	1	12	12	100	12	100
10	3	3	2	25	25	23	11	11	9	22	21	17	12	12	10	4	4	1	1	1	1	78	77	99	63	81
9	30	28	2	85	82	11	75	70	23	75	66	25	37	33	20	31	29	9	22	13	0	355	321	90	90	25
8	95	27	2	117	77	0	150	81	6	100	49	0	69	38	3	46	16	2	68	14	0	645	302	47	13	2
7	108	0	0	60	12	0	127	10	0	63	9	0	48	3	0	27	1	0	89	2	0	522	37	7	0	0
Total	236	58	6	291	200	38	364	173	39	263	148	45	168	88	35	109	51	13	181	31	2	1612	749		178	

Table II. **Length of Oysters dredged by the**

Date	13/4	15/4	9-10/10	11/4	15/8	10/4	23/4	28/8	11/10	6/4	8/4	22/4	27/5	12/8	1-8/10	9/4	20/4	23/5
	Volstrup.			Langer-Hage		Revelkær-Hage				Trehuse						Feggeklit		
Depth in fathoms	2		1½—2	2½	1½—3½	2½	2–4	2–4	2—4	2½—4	3	2½		3	2—3 1½—2	3	3	
No of hauls	9					2	4	1		1	2	4		8—10	2+6	3	2	
minutes:	90		120			20	25	10	20	15	20	40			15+60	30	20	
Length	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.
15 cm.	....	....	.....	.....	.....	....	....	....	....	.....	.....	.....	.....	.....	.....	....	....	....
14 —	....	....	.....	.....	.....	....	....	....	....	.....	.....	.....	.....	.....	.....	....	....	....
13 —	....	....	.....	.....	.....	....	....	....	....	1	.....	.....	.....	.....	.....	1	....	....
12 —	4	....	2	1	1	....	....	....	....	0	1	.....	.....	2	5	4	3	2
11 —	32	....	27	12	2	1	1	....	1	22	8	7	13	9	18	18	22	24
10 —	85	36	58	12	15	16	7	4	12	47	20	17	33	39	38	**26**	34	**44**
9 —	**125**	50	**81**	39	39	36	22	23	**32**	**75**	**42**	41	**94**	47	**67**	21	**35**	40
8 —	91	**54**	47	**43**	**48**	**67**	**44**	**28**	27	**75**	33	**62**	73	**51**	57	20	25	33
7 —	35	20	19	23	16	37	24	24	23	55	33	31	50	29	29	3	12	8
6 —	12	....	14	8	5	11	7	9	13	22	5	9	11	11	21	1	1	3
5 —	19	....	15	5	9	8	5	16	19	11	9	6	10	24	47	4	0	4
4 —	14	....	10	8	15	5	2	19	9	27	23	19	19	36	59	12	5	3
3 —	23	....	9	10	8	14	1	8	5	65	44	25	27	19	37	23	4	8
2 —	15	....	7	7	6	22	3	4	6	37	40	12	20	8	37	11	1	....
1 —	2	....	7	8	.....	26	1	2	....	12	39	2	4	.....	4	4	....	....
	457	160	596	176	164	243	117	137	147	449	297	231	354	275	419	148	142	169

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$^{23}/_{8}$	$^{24_25}/_{9}$	$^{10}/_{4}$	$^{12}/_{10}$	$^{27}/_{4}$	$^{14}/_{10}$	$^{15}/_{4}$	$^{16}/_{4}$	$^{13_14}/_{5}$	$^{6}/_{5}$	$^{7}/_{5}$	$^{7}/_{5}$	$^{17}/_{4}$	$^{4}/_{10}$	$^{11}/_{5}$	$^{11}/_{5}$	$^{8_11}/_{10}$	
east		Sennels-bank		Kjeld-gaard		Røjensø Odde	Toftum Bakker	Nissum Bredning	Lundø Hage	From Knudshoved to Bregnedals Hage	From Nakken to Ertbølle Hoved	Fur Hoved	Fur North	Livø to Holmtangen	Hannæsbank	Amtofte Reef	Number and Length
4	4	3—3½		3		2—3	3		2—3	3	3—5	3	4—4½		4—4½	4—4½	
		3 30	80	4 40	6 60		4 40	4				3 30	1 20		3	2 25	Total
Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num	Num.	Num.	Num.
....	.....	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	....	.....	.....	.....	.....	1
....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2
....	.....	.....	.....	.....	.....	2	1	2	.....	.....	.....	1	.....	.....	.....	.....	8
2	7	.....	1	.....	1	10	4	0	.....	1	1	6	1	1	.....	1	61
12	25	10	13	1	4	8	18	12	.....	2	6	24	5	7	4	1	369
29	**43**	12	24	23	17	**24**	29	13	.....	**5**	23	32	**7**	**10**	21	8	863
39	34	**41**	65	49	37	11	**42**	**18**	2	3	**67**	**62**	4	9	43	21	**1456**
26	20	38	**70**	**62**	**61**	6	25	9	5	1	51	38	1	6	**55**	**28**	1380
7	14	29	27	40	26	1	12	2	5	4	31	19	2	3	32	17	742
2	12	8	13	9	31	2	4	2	11	.....	11	9	7	1	5	10	300
6	13	0	32	4	24	.....	3	.....	6	.....	10	5	2	1	3	4	324
8	5	0	17	9	20	.....	1	.....	16	.....	7	7	6	0	0	2	383
4	4	6	11	11	9	.....	4	.....	9	.....	6	8	6	1	0	3	412
....	2	7	7	3	11	.....	1	.....	4	.....	5	11	1	.....	1	4	293
....	.....	15	3	2	4	.....	.....	.....	.....	.....	2	8	3	.....	.....	2	150
135	179	166	283	213	245	67	144	58	58	16	220	230	45	39	164	101	6744

Table III. **Length and number of all the Oysters taken by**

Date	28/5	28/5	29/5	29/5	6/7	6/7	9/7	9/7	10/7	10/7	10/7	11/7	11/7	12/7	12/7	
	N.o. Teglværket, N.o. Nykøbing, Draaby Vig, Livø Bredning	Trehuse-Banken, Sallingsund	E. of Feggeklit Løgstør Bredning	Hannæs-Bank Løgstør Bredning	Revelkær Hage, Visby Bredning	Svalklit, Thisted Bredning	Volstrup, Venø Bugt	Volstrup, Venø Bugt	Nygaards Hage, Venø Bugt	N. of Rønnen, Nissum Bredning	S. of Mullerne, Nissum Bredning	Gammellund, Kaas Bredning	Off Spottrup, Kaas Bredning	N. o. Nakken Risgaards Hage Risgaards Bredning	Rindgrund (north point), Risgaards Bredning	
Depth in fathoms	3	3	4	4½	3	3	3	2	3	3	3	2½	2	3	3	Total
Length	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	Num.	
14 cm.	.....	.....	.....	.....	.....	.. * .	1	.....	.....	.....	.. * .	.....	.....	.....	.....	1
13 —	.....	.....	1	.....	.....	.....	9	.....	.....	.....	1	2	.....	.....	.....	13
12 —	2	10	4	2	.....	.....	29	1	.....	.....	7	3	1	.....	.....	59
11 —	9	32	16	3	4	1	38	6	3	6	**13**	14	8	.....	3	156
10 —	40	51	**28**	41	26	7	**67**	24	14	16	10	21	36	4	16	401
9 —	107	97	25	117	101	13	56	39	20	**25**	8	25	109	**24**	81	847
8 —	**194**	**109**	23	**124**	**136**	**19**	65	**48**	**47**	17	2	**26**	**207**	23	**151**	**1191**
7 —	111	81	15	63	111	3	30	16	**47**	5	2	10	115	5	122	736
6 —	20	20	3	22	46	3	16	19	16	3	.....	3	29	3	34	237
5 —	25	10	2	10	36	.....	22	25	14	6	.....	6	11	.....	7	174
4 —	31	23	5	6	71	2	24	11	13	.....	.....	2	9	.....	6	203
3 —	41	33	5	10	70	3	11	13	11	.....	1	3	5	.....	10	216
2 —	28	13	8	2	27	.....	7	10	4	.....	.....	2	.....	1	3	105
1 —	3	2	.....	1	11	2	6	1	.....	.....	.....	.....	.....	.....	1	27
Total	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* not tested by the standard.

diving in spring and summer 1907.

tested by the standard	Standard oysters.			
	with 7 × 3 cm. standard		with 8 × 3 cm. standard	
	Num.	%	Num.	%
Num.				
* 1	1	100	1	100
12	12	100	12	100
52	52	100	52	100
142	142	100	142	100
384	384	100	367	96
826	797	96	**579**	70
1170	**920**	79	313	27
731	210	29	19	3
3318	2520		1485	

* The details are given in Table III a.

Table IV.

The oyster banks in		Estimated area and number: Area in millions of □ foot	Density pr. □ foot	Oysters over 7 cm. (in millions)
Livø Bredning	have	$4 \times 50_{.0}$	$0_{.075}$	$15_{.00}$
Sallingsund	—	$4 \times 20_{.8}$	$0_{.11}$	$9_{.15}$
Løgstør Bredning	—	$4 \times 89_{.0}$	$0_{.07}$	$24_{.92}$
Visby do.	—	$4 \times 23_{.3}$	$0_{.11}$	$10_{.25}$
Thisted do.	—	$4 \times 48_{.0}$	$0_{.025}$	$4_{.80}$
Venø Bugt	—	$4 \times 43_{.1}$	$0_{.06}$	$10_{.78}$
Nissum Bredning	—	$4 \times 116_{.6}$	$0_{.02}$	$7_{.58}$
Kaas do.	—	$4 \times 7_{.1}$	$0_{.07}$	$2_{.11}$
Risgaards do.	—	$4 \times 20_{.8}$	$0_{.05}$	$4_{.47}$
Total...		$4 \times 419_{.0}$ = $2_{.91}$ □ miles	(0.07)	$89_{.06}$

Thus, according to Table IV the oyster banks in the Lim Fjord have a total area of ca. $2_{.9}$ Danish □ miles with a stock of ca. 89 million oysters of 7 cm. and above. Fron the measurements we find that of these:

$\frac{2520}{3318}$ = ca. 76 % = ca. **67**$_{.5}$ millions **7 × 3 cm. oysters.**

$\frac{1485}{3318}$ = ca. 45 % = ca. **40** millions **8 × 3 cm. oysters.**

Table III a. **Length and number of Oysters 7 cm. and above,**

	N. of Teglværket, N. of Nykøbing, Draaby Vig, Livø Bredning			Trehuse-Bank, Sallingsund			E. of Feggeklit, Løgstør Bredning			Hannæsbank, Løgstør Bredning			Revelkær Hage, Visby Bredning			Svalklit, Thisted Bredning	Volstrup, Vens Bugt		
Date	28/5			28/5			29/5			29/5			6/7			6/7	9/7		
cm.	Total Num. »N«.	Num. 7×3 cm. M.Ø.=St.	Num. 8×3 cm. M.Ø.=St.	Total Num. »N«.	Total 7×3 cm. M.Ø.=St.	Num. 8×3 cm. M.Ø.=St.	Total Num. »N«.	Num. 7×3 cm. M.Ø.=St.	Num. 8×3 cm. M.Ø.=St.	Total Num. »N«.	Num. 7×3 cm. M.Ø.=St	Num. 8×3 cm. M.Ø.=St.	Total Num. »N«.	Num. 7×3 cm. M.Ø.=St.	Num 8×3 cm. M.Ø.=St.	Total Num. »N«.	Total Num. »N«.	Num. 7×3 cm. M.Ø.=St.	Num. 8×3 cm. M.Ø.=St.
Length																			
14	—	—	—	-		—	—	—	-	—	—	—	—	—	—	—	1	1	1
13	—	—	—	-	—	—	1	1	1	—	—	—	—	—	—	—	9	9	9
12	2	2	2	10	10	10	4	4	4	2	2	2	—	—	—	—	29	29	29
11	9	9	9	32	32	32	16	16	16	3	3	3	4	4	4	1	38	38	38
10	40	40	37	51	51	51	28	28	28	41	41	38	26	26	26	7	67	67	62
9	107	101	73	97	96	84	25	23	20	117	112	61	101	100	79	13	56	56	41
8	194	156	57	109	95	34	23	19	6	124	79	18	136	117	49	19	65	52	15
7	111	33	0	81	29	3	15	3	0	63	13	5	111	29	2	3	30	15	0
Total...	463	341	178	380	313	214	112	94	75	350	250	127	378	276	160	43	295	267	195
Area A □ feet	ca. 6200			ca. 3400			ca. 5720			ca. 3200			ca. 3400			ca. 1800	ca. 3400		
Density N:A.	$0_{\cdot 075}$			$0_{\cdot 11}$			$0_{\cdot 03}$			$0_{\cdot 11}$			$0_{\cdot 11}$			$0_{\cdot 025}$	$0_{\cdot 09}$		
Average density pr. Bredning	$0_{\cdot 075}$			$0_{\cdot 11}$			$0_{\cdot 07}$						$0_{\cdot 11}$			$0_{\cdot 025}$			

taken by diving in spring and summer 1907 at the places mentioned:

Volstrup, Venø Bugt			Nygaards Hage, Venø Bugt			N. of Rønnen, Nissum Bredning			S. of Mullerne, Nissum Bredning	Gammellund, Kaas Bredning			Off Spøttrup, Kaas Bredning			N. of Nakken, Risgaards Hage, Risgaards Bredning			Rindgrunds Nordspids, Risgaards Bredning			
9/7			10/7			10/7			10/7	11/7			11/7			12/7			12/7			
Total Num. »Ne.	Num. 7×3 cm. MØ. = St.	Num. 8×3 cm. MØ. = St.	Total Num. »Ne.	Num. 7×3 cm. MØ. = St.	Num. 8×3 cm. MØ. = St.	Total Num. »Ne.	Num. 7×3 cm. MØ. = St	Num 8×3 cm. MØ. = St.	Total Num. »Ne.	Total Num. »Ne.	Num. 7×3 cm. MØ. = St.	Num. 8×3 cm. MØ. = St.	Total Num. »Ne.	Num. 7×3 cm. MØ. = St.	Num. 8×3 cm. MØ. = St.	Total Num. »Ne.	Num. 7×3 cm. MØ. = St.	Num. 8×3 cm. MØ. = St.	Total Num. »Ne.	Num. 7×3 cm. MØ. = St.	Num. 8×3 cm. MØ. = St.	
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	1	2	2	2	—	—	—	—	—	—	—	—	—	
1	1	1	—		—	—	—	—	7	3	3	3	1	1	1	—	—	—	—	—	—	
6	6	6	3	3	3	6	6	6	13	14	14	14	8	8	8	—	—	—	3	3	3	
24	24	23	14	14	13	16	16	14	10	21	21	21	36	36	34	4	4	4	16	16	16	
39	37	25	20	19	16	25	24	15	8	25	25	23	109	101	58	24	24	22	81	81	62	
48	28	5	47	40	11	17	9	3	2	26	21	11	207	148	38	23	16	6	151	140	60	
16	1	0	47	12	1	5	0	0	2	10	3	0	115	25	0	5	1	0	122	46	8	At Svalkilt and Mullerne the oyster standard was not used; altogether it was used with 3404—(2 × 33) = 3318.
134			131			69			43	101			476			56			373			Total 3404
	97			88			55				89			319			45			286		— 2520
		60			44			38				74			139			32			149	— 1485
ca. 2520			ca. 2800			ca. 2800			6200	ca. 700			ca. 4400			ca. 4000			ca. 4000			
0.05			0.05			0.025			0.01	0.035			0.11			0.015			0.9			Average density Tm. = 0.248
0.06						0.02				0.07						0.05						

Appendix A.

Statistics of the number of oysters taken by the lessees during the last 7 years, from $19\frac{00}{01}$ to $19\frac{06}{07}$.

The statistics show that the oysters in the Lim Fjord have been chiefly taken in recent years by means of diving and dredging; pole-dredging has only been of subordinate importance and has not been carried on at all in certain years. The reason is not that the fishermen have no desire to pursue this method of fishing, but the lessees could obtain a sufficient number of oysters with the dredging and diving boats belonging to them. As will be seen, most of the oysters are obtained by diving; Thisted Bredning with the large Livø Bredning (Livø and Løgstør Bredning together) with Fuur Sund yield the largest quantities of oysters (diving). Dredging which has considerably increased since $19\frac{03}{04}$ proceeds mainly on the large banks N.E. of Feggeklit in Livø Bredning. Each year a certain portion of the Lim Fjord is quite closed to fishing; the lessees themselves propose what portion. We can see nothing in these statistics which would indicate that the quantity of oysters has anywhere decreased, even at the places most fished; even the large dredged bank N.E. of Feggeklit seems to remain just as rich, although dredging is carried on there every year. The reason why so much dredging is done there is that the true dredgers have permission from the Government only to fish there and in Nissum Bredning; this bank lies nearer the depot (Nykøbing) than Nissum Bredning. It will be noted in the statistics that dredging was carried on a single time outside these two localities; this occurred because the diving boats have also permission under unfavourable conditions when the water is not clear enough for diving to fish with the dredges.

As exactly the same boundaries are not maintained in the statistics each year, for example in Livø Bredning, Risgaards Bredning etc., we can only place general reliance on the data. It seems to be the rule that most oysters are obtained on the banks which look towards the west and north, thus right on the west and north coasts of the land. Of such banks well-fished by divers may be mentioned the banks in Thisted Bredning east and south, in Venø Bugt south and east, in Risgaards Bredning east, in Fuur Sund east, in Vilsund east. The reason for this, I should imagine, is that there is very little growth of weed here, the prevailing westerly and northerly winds causing so severe a wave-motion that the vegetation is kept under more than on the coasts sheltered from these winds. Several things I have noticed during this past year whilst dredging seem to indicate in my opinion that there is in general a less dense growth of weed on the coasts named. This weed (Zostera) is naturally also a great hindrance in the way of the divers, preventing them from seeing and working; but whether there are really fewer oysters on the coasts mentioned than on the others, that is another question. It will probably be very good for the oyster banks if the growth of the weed were kept down at many places by means of dredging. I may mention in this connection. that it might well pay to sell the weed dried to foreign countries as packing material. This is done in the Lim Fjord or was at least a short time ago. It is possible that more might be done with this industry.

Statistics of the number of Oysters fished by the lessees from the season $19\frac{00}{01}$ to $19\frac{06}{07}$.

Number in thousands	1900—01			1901—02			1902—03			1903—04			1904—05			1905—06			1906—07			diving	dredging	pole-dredging
	diving	dredg.	pole-dredg.	diving	dredg.	pole-dredg.	diving	dredg.	pole-dredg.	diving	dredg.	pole-dredg.	diving	dredg.	pole-dredg.	diving	dredg.	pole-dredg.	diving	dredg.	pole-dredg.			
Nissum Bredning	....	110	....	0	0	0	109	....	....	0	0	0	103	134	....	55	....	....	118	....	....	385	244	.....
Venø Bugt	9	....	....	161	....	50	328	....	18	14	....	....	120	....	....	81	....	....	131	....	....	844	.....	68
Kaas Bredning	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	140	....	....	110	....	....	.....	.....	.....
Sallingsund	....	....	....	135	....	26	49	....	80	93	....	....	146	....	....	....	....	....	....	....	....	770	.....	120
	0	0	0	....	....	....	....	....	....	....	....	....	....	....	14	60	....	....	30	....	....	.....	.....	.....
Thisted Bredning	236	....	....	138	44	....	85	....	....	51	....	....	0	0	0	250	....	8	294	....	....	1054	44	48
Vilsund and Visby Bredning	....	....	13	....	....	....	....	....	....	....	....	....	....	....	....	0	....	....	....	....	....	.....	.....	.....
	187	....	27	196	....	....	0	0	0	69	....	....	10	....	....	....	0	0	20	....	....	482	.....	.....
Fuur Sund	....	....	....	....	....	10	....	....	23	....	....	....	0	0	0	....	....	....	....	....	....	.....	.....	100
Livø Bredn. and Løgstør Bredn.	125	....	1	144	....	....	123	....	....	183	....	....	....	....	....	337	....	66	219	....	....	1368	.....	.....
	....	9	....	....	144	....	....	195	....	52	548	....	185	357	....	....	191	....	....	384	....	.....	1828	....
Risgaards Bredning	285	....	....	85	....	....	14	....	....	80	....	....	0	0	0	51	....	....	62	....	....	577	.....	0
Total thousands	849	119	14	859	188	86	708	195	121	542	548	0	564	491	14	974	191	74	984	384	0	5480	2116	336
Total	ca. 1,009,000			ca. 1,133,000			ca. 1,024,000			ca. 1,090,000			ca. 1,069,000			ca. 1,239,000			ca. 1,368,000			ca. 7,932,000		

Thus a little over 1 million annually.

C. G. Joh. Petersen: Om de skalbærende Molluskers Udbredningsforhold i de danske Have indenfor Skagen 1888. 8°. 1162 pg. 2 Kort.

Det videnskabelige Udbytte af Kanonbaaden »Hauch«s Togter i de danske Have indenfor Skagen. 1893. 4°. 464 pg. Atlas i folio.

Indhold: Echinodermata (Petersen), Diatomeer (Cleve), Undersøgelse af nogle Bundprøver (Rørdam), Mollusca (Petersen), Cephalopoda (Posselt), Crustacea malacostraca (Meinert), Hydrografi (Rørdam), Polyzoa (Levinsen), Ascidiæ simplices (Traustedt), Annulata, Hydroidæ, Anthozoa, Porifera (Levinsen), Nogle alm. Resultater (General Results. Engl.) (Petersen).

C. F. Drechsel: Oversigt over vore Saltvandsfiskerier med Kort og Planer. 1890. 4°. 100 pg. Med et Tillæg: »Om Naturforholdene indenfor Skagen« af *C. G. Joh. Petersen.* Med Kort. 4°. 46 pg.

Fiskeri-Beretning for 1888—89, 89—90, 90—91, 91—92, 92—93, 93—94, 94—95, 95—96, 96—97, 97—98, 98—99, 99—1900, 1900—01, 1901—02, 1902—03, 1903—04, 1904—05, 1905—06, 1906—07.

Beretning fra den danske biologiske Station I (1890—91)—XI (1900—1901) findes i de tilsvarende Fiskeri-Beretninger.

I. Fiskenes biologiske Forhold i Holbæk Fjord. 1890—91. 63 pg. Med et Kort.
II. Om vore Kutlingers (*Gobius*) Æg og Ynglemaade. 1892. 9 pg. Med 2 Tavler.
II. On the Eggs and Breeding of our Gobiidæ. 1892. 9 pg. Two Plates.
III. Det pelagiske Liv i Fænø Sund etc. 1893. 38 pg. Tabeller.
III. The Pelagic Life in Fænø Sound etc. 1893. 38 pg. Tables.
IV. Om vore Flynderfiskes Biologi og om vore Flynderfiskeriers Aftagen. 1894. 146 pg. 2 Tavler. 1 Kort og mange Tabeller.
IV. On the Biology of our Flat-fishes and on the decrease of our Flat fish Fisheries. 1894. 146 pg. 2 Plates. 1 Chart. Many Tables.
V. Den alm. Aal (*Anguilla vulgaris* T.) anlægger før sin Vandring til Havet en særlig Forplantningsdragt. 1896. 35 pg. Med 2 Tavler.
Etc. 64 pg.
V. The common Eel (*Anguilla vulgaris* T.) gets a Particular Breeding-dress before its Emigration to the Sea. 1896. 35 pg. With 2 Plates.
Etc. 64 pg.
VI. Om Rødspætteyngelens aarlige Indvandring i Limfjorden etc. 1887. 49 pg. 1 Kort. 2 Tabeller.
VI. The Yearly Immigration of young Plaice into the Limfjord etc. 1897. 48 pg. 1 Chart. 2 Tables.
VII. Plankton-Studier i Limfjorden. 1897. 23 pg. 1 Kort. 4 Tabeller.

VII. **Separat.** *C. G. Joh. Petersen:* Plankton Studies in the Limfjord. 1897. 23 pg. 1 Map. 4 Tables.

VIII. Om et Skovl-Vaad til Undersøgelse af dybere Farvande. 1898. 24 pg. 10 Figurer.

VIII. **Separat.** *C. G. Joh. Petersen:* An Otter-Seine for the Exploration of Deeper Seas. 1898. 24 pg. With 10 Figures.

IX. Travlinger i Skagerak og det nordlige Kattegat i 1897 og 98. 1899. 56 pg. 1 Kort.

IX. **Separat.** Trawlings in the Skager Rack and the Northern Cattegat in 1897 and 98. 1899. 56 pg. With One Map.

X. Fortegnelse over Aalerusestader i Danmark etc. — Mindre Meddelelser. 1899 og 1900. 36 pg. Et farvetrykt Kort.

X. List of The "Aalerusestader" in Denmark, etc. — Smaller Communications. 1899 and 1900. 37 pg.

XI. I. Torskens Biologi i de danske Farvande. II. Om andre Torskefisk i vore Farvande. III. Nogle almindelige Betragtninger om Fredning, Lovgivning etc. IV. Ændringer og Forbedringer af Skovl-Vaad til zoologisk Brug. 1900 og 1901. 44 pg.

XI. I. The Biology of the Cod in the Danish Seas. II. On other Codfishes in our Seas. III. Some General Observations on Protection, Legislation etc. IV. Alterations and Improvements on Otter-seines for Zoological Purposes. 1900 and 1901. 44 pg.

XII. I. Hvor og under hvilke Forhold kunne Rødspættens Æg udvikle sig til Unger indenfor Skagen? 1 Kort. II. Smaahvarrernes (*Zeugopterus*-Slægtens) Unger. 1 Tavle. III. Kunne vi optage Konkurrencen med Udlandets Damptrawlere i vore Farvande udenfor det danske Søterritorium? 1902 og 1903. 36 pg.

XII. I. Where, and under what Conditions, can the Eggs of Plaice be developed into Young Fish within the Skaw? II. On the Young Stages of the genus *Zeugopterus*. (With one Plate.) III. Can we enter into Competition with the Foreign Steam-trawlers in our Seas outside the Danish Territorial Limit. 1902 and 1903. 33 pg.

XIII. Fiskeæg og Fiskeyngel i de danske Farvande. (Undersøgelser i 1904 og tidligere Aar.) 1903 og 1904. 81 pg.

XIII. Eggs and Young of Fishes in the Danish Waters. (Investigations during 1904 and earlier years.) 1903 and 1904. 85 pg.

XIV. I. Om Lysets Indflydelse paa Aalens Vandringer. II. Om Aalens Alder og Vækst. 1906. 39 pg.

XIV. I. The Influence of Light on the Migrations of the Eel. II. Age and Rate of Growth of the Eel. 1906. 39 pg.

XV. Studier over Østersfiskeriet og Østersen i Limfjorden. Med et Kort, Temperaturkurver, 3 Tabeller og 2 Tekstfigurer. 1907. 70 pg.

XVI. Aalegræssets *(Zostera marina's)* Vækstforhold og Udbredelse i vore Farvande. 1908. 61 pg.